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Heating Piping & Air Conditioning

DESIGN
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FEBRUARY ★ 1943

INDUSTRIAL
COMMERCIAL
AND LARGE
BUILDINGS

93: Journal Section, American Society of Heating and Ventilating Engineers

How to determine cost of overtime heat in industrial buildings—page 67

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128 YARWAY IMPULSE TRAPS at St. Croix Paper Co.

WINTERS are really cold in Woodland, Maine, up on the Canadian border, but Yarway Impulse Traps handle the heavy condensate load with dispatch at the St. Croix Paper Company Plant. 128 Yarway Impulse Traps are in use at this plant—draining unit heaters, air preheaters, steam mains and other equipment.

More than 180,000 Yarways Have Been Sold . . .

. . . purchased on their performance. Users report that *quicker heating* and *greater sustained heating efficiency* soon pay for their installation and continue to return worthwhile profits in plant operating economy. Then, too, the Yarway Trap's *small size saves space*. Its *light weight simplifies installation*. Its unique design with *only one moving part*, and its *rugged bar-stock construction*, keep down maintenance expense.

Good for all pressures over wide range without change of valve or seat—it may be used on any constant or fluctuating pressures.

And when you consider that their *purchase price* is usually *no more than the cost of repairing an ordinary trap* —why not get Yarway performance for your money?

A nearby Mill Supply Dealer handles Yarway Impulse Traps and will be glad to serve you. Or write for Catalog T-1737.

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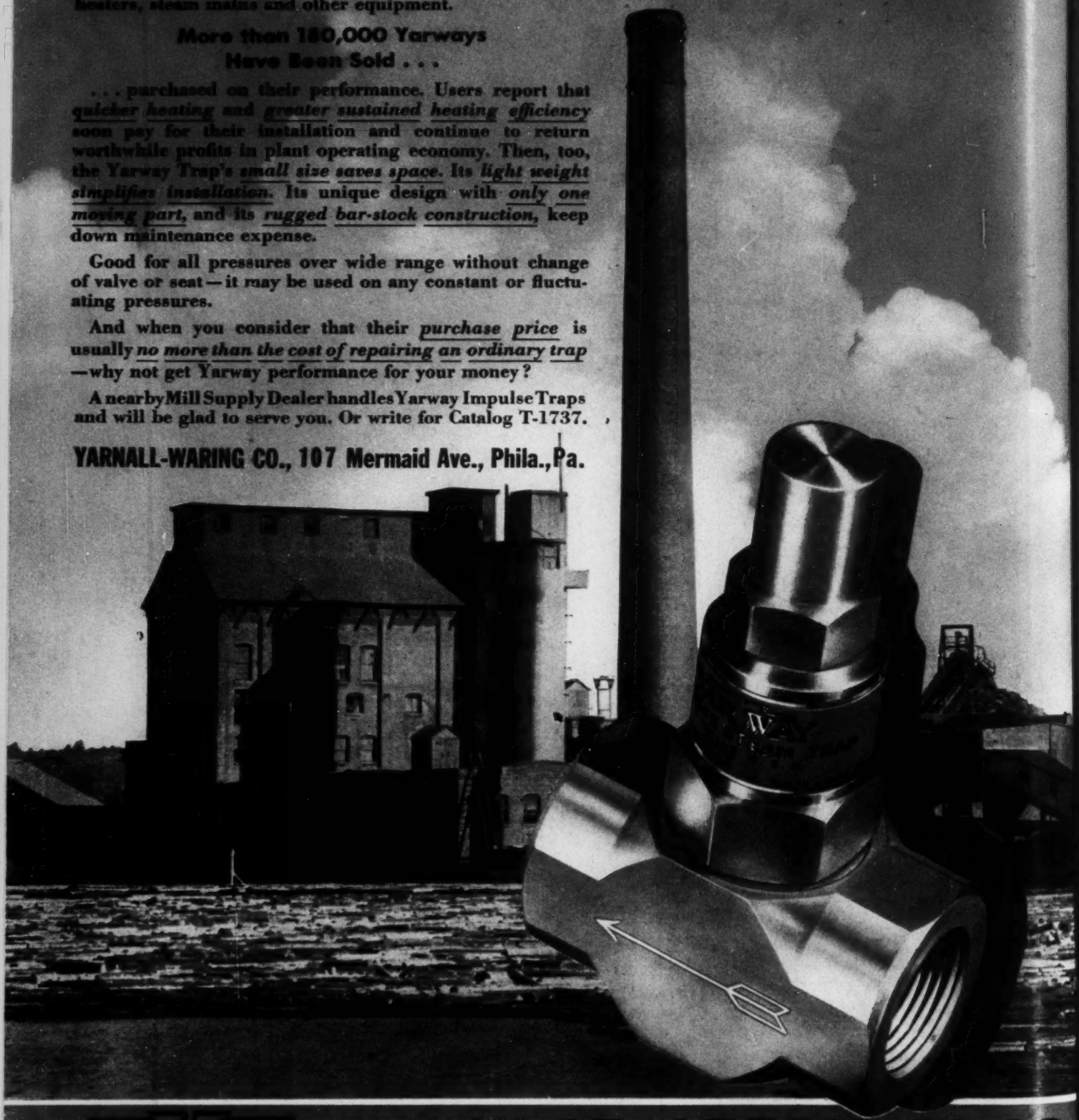

YARWAY IMPULSE STEAM TRAP

THE EDITOR'S PAGES

MAGAZINE PAPER CONSUMPTION LIMITED

The editorial content of Heating, Piping & Air Conditioning has—since the first issue after Pearl Harbor—been increasingly devoted to strictly wartime applications. For many months before the declarations of war, during the "defense" period, editorial attention in ever-increasing volume was given to such subjects as air conditioning blackout plants, fuel economy in oil fired heating plants, preventive piping maintenance for full-time production, conservation, production for national defense, etc.

During 1943, the physical format of HPAC will also reflect war conditions. Magazine publishers are required by a WPB order dated December 31, 1942, and received during the early part of January, to restrict their paper consumption to 90 per cent of their 1942 use. First of the major changes in meeting the terms of this order will be the new trim size of 8⅛ by 11¼ inches, effective with our April issue. The size of the type page will be unchanged, but margins will be noticeably smaller.

No reduction in the amount or quality of information offered to HPAC's readers is contemplated. Articles will be edited to give the same or more data in less space. Fewer illustrations, carefully selected, will conserve paper as well as copper and zinc. Wartime restrictions can often lead to incidental — but distinct — improvements, necessity being the mother of invention. It is the aim of HPAC's staff to approach the problem in this way.

Last month's 1943 Directory Number of HPAC included the largest directory section of heating, piping, and air conditioning equipment for industry and big buildings which we have ever published — and this has been an annual feature for nine years. Despite the biggest directory section in all its history, plus the regular editorial material and ASHVE Journal Section — and a paid advertising count practically the same as in January, 1942—the total number of pages in January this year was kept 22 pages under the preceding January; this, with other economies, resulted in a worthwhile paper conservation.

PREFERENCE RATING FOR AIR CONDITIONING REPAIRS

The War Production Board amended January 19 preference rating order P-126 to facilitate acquisition of material for the emergency repair servicing of industrial and commercial refrigerating or air conditioning systems. According to the order, emergency repair service means the repair of any installed system when, subsequent to its installation and operation, a breakdown occurs therein, or is immediately threatened.

Higher preference ratings are assigned for the emergency repair of refrigerating and air conditioning systems used for specified purposes under the terms of the order. Emergency service agencies cannot deliver any metallic replacement parts unless the owner of the system turns in the old part immediately upon installation of the new in order that such old parts may be repaired, reconditioned or disposed of to a scrap dealer.

No ratings are provided for delivery of parts for the repair or maintenance of any comfort cooling system, which systems are defined in the order. However, where the part may be necessary and used for the circulation of air, or necessary and used for raising the temperature of air during cold weather to a degree which is tolerable or comfortable for persons (comfort heating), it is not considered as included under the term "comfort cooling system."

Among the applications which are assigned an AA-2X rating for deliveries of material for emergency repair service are the continued operations of the "dry blast" in a blast furnace, and the continued operations of a plant or factory engaged in industrial or commercial processing of materials or products for delivery under "defense orders" as defined in priorities regulation No. 1.

AIR CONDITIONING ESSENTIAL FOR GAGE INSPECTION ROOMS

The Taft-Peirce Mfg. Co., one of America's oldest special machine and tool manufacturing organizations, is utilizing air conditioning to insure the precision of gages and tools, according to the Carrier Corp.

One of the first to recognize the value of air conditioned inspection rooms, the company has completed a new building which houses an air conditioned inspection and lapping room.

Explaining that constant temperature, humidity, and cleanliness of air in inspection rooms contribute importantly to the company's reputation for accuracy and quality of workmanship, a Taft-Peirce official comments: "In rooms where measurements must be made to one ten-thousandth part of an inch, cleanliness of air and constant temperature are of the utmost importance if stability of the product is to be maintained during inspection. Control of both temperature and humidity prevents corrosion due to precipitation of moisture from the air. For 14 years, we have used air conditioning equipment in the production of precision tools and gages for which our company is so well known. That precision is more vital today than ever before."

SALVAGE COMMITTEE FOR CORK INDUSTRY

The industrial salvage branch of the salvage division of the War Production Board has recently organized a salvage committee in the cork industry under the chairmanship of Joseph J. Mundet, Jr., president of the Mundet Cork Corp., for the New York area.

The industry program consists of locating, collecting, segregating, and disposing of all types of such critical materials as iron and steel, nonferrous metals, rubber, burlap, manila rope, obsolete machinery, tools, dies, jigs, and equipment.

THE EDITOR'S PAGES

Continued

WPB DISTRIBUTES CONTROLLED MATERIALS LIST

The War Production Board began January 7 nationwide distribution of the official controlled materials plan "class B" product list. The list includes some 500 groups of related items classified as "B" products, and will be used by manufacturers operating under CMP to determine whether they are "class A" or "class B" producers.

Only those products containing controlled materials which are included in the official list are "class B" products. All other products containing controlled materials are, by definition, "class A" products. Under CMP, manufacturers of "A" products will receive their allotments of materials from the claimant agency or agencies under whose programs they are operating. "B" producers, on the other hand, will receive their allotments from the appropriate industry divisions of the War Production Board.

Dated December 21, the "class B" list includes, among many other products, the following:

Pumps, measuring and dispensing.

Compressors and dry vacuum pumps, reciprocating—air and gas (excluding compressors for air conditioning, ice making, food and beverage cooling, processing and preservation and cold storage systems).

Double acting reciprocating compressors and vacuum pumps.

Single acting reciprocating compressors, large (including portable, semi-portable and stationary compressors of 15 hp or over).

Single acting reciprocating compressors, small (including portable, semi-portable and stationary compressors under 15 hp).

Pumps, industrial (except measuring and dispensing, and reciprocating compressor and dry vacuum pumps).

Fans, blowers and exhausters (except turboexhausters, and domestic propeller type fans).

Dust collecting equipment, industrial.

Power transmission equipment, mechanical (other than speed changers)—including clutches, chain drives, belt drives, open gear drives, and line shaft equipment, only when these are delivered separate from other equipment.

Speed changers—worm, helical, herringbone, spur, variable speed (including only those that are delivered separate from other equipment).

Bearings, ball and roller (except main thrust bearings for ships).

Stokers, industrial (over 36 sq ft grate area).

Condensers, steam—surface, jet and barometric (excluding pumps and instruments).

Heat exchangers, including: atmospheric sections and open sections, condensers (excluding surface condensers of prime mover exhaust steam); coolers (excluding compressor intercoolers, radiator type coolers, unit coolers and ventilators, and blast coils); heaters (excluding domestic hot water heaters, service water heaters, and indirect water heaters); contactors, distillers, evaporators, heat reclaimers, reactors, reboilers, reflux condensers, steam generators, converters, and all similar equipment (excluding all heat exchangers used on mechanical refrigeration and air conditioning units).

Motors and generators.

Electric motor controls, electric motor control equipment (except gunfire controls and aircraft controls), including starters, contactors, relays, controllers, control panels, assemblies of motor controllers in dead front cubicles or control centers, compensators, speed regulators, overload relays, drum switches, resistant units for motor control, pushbutton stations, pressure switches, float switches, limit switches, master switches, solenoids, and rheostats.

Air conditioning and refrigeration equipment. Refrigerators, ice (domestic). Refrigeration and air conditioning equipment, including refrigerators and air conditioning heat exchangers, but excluding domestic refrigerators.

Pipe fittings, steel.

Pipe fittings, except steel.

Valves (except instrument regulating, refrigeration and air conditioning, automotive and tire).

Steel valves.

Valves (except steel).

Boilers, low pressure, cast iron (under 100 psi).

Boilers, low pressure, steel (under 100 psi).

Coils, blast heating.

Convectors, heating.

Radiators, cast iron.

Unit heaters and unit ventilators.

Warm air distribution equipment, registers, stove and smoke pipe.

Warm air furnaces, including furnace burner units, as defined by WPB order L-22.

Burners, gas and oil (not including gas, oil control or regulating valves, or connecting piping or domestic types).

Burners, gas.

Burners, oil, industrial.

Burners, combination oil and gas, industrial.

Automatic fuel burning equipment (domestic).

Gas conversion burners; defined as any burner designed to supply gaseous fuel to any equipment that has been redesigned for the purpose of heating a building or for cooking or for hot water supply and that was originally designed to use another fuel.

Oil burners; defined as any device which is designed and produced for the purpose of burning oil (including any device which is a part of a boiler-burner unit or a furnace-burner unit).

Stokers, domestic (grate area 36 sq ft or less).

Heating system controls, including thermostats and other temperature control devices.

Instruments. Indicating, recording, and controlling instruments and associated accessories (except watches and clocks and optical instruments) for measuring or determining or regulating temperatures, pressure, flow, liquid level, humidity, movement, time, rate, position, and electrical quantities. (Excludes domestic thermostats and domestic refrigeration controls, gas and water meters, aircraft and navigation instruments).

Control valves and regulators, industrial type (for plant facilities, etc.).

Instruments, industrial type (for plant facilities, etc.).

Meters, gas and water.

Metallic tubing and hose, flexible.

STOKER MAKER OFFERS SALES ENGINEERING HELP

Today's fuel oil shortage has set up a pressing need for stokers—in fact, the government has requested the full cooperation of the stoker industry in speeding up conversion to coal in the vitally affected areas.

To clear up the confusion as to who can have stokers, the U. S. Machine Corp., makers of Winkler stokers, has just completed a series of meetings in New York, Boston, and Chicago. In these sales engineering short courses, the problem was approached from the three basic angles: how and where to sell stokers, and the technical details involved in their application.

Those who missed the meetings may write to the factory at Lebanon, Ind., for complete information on the program.

Heating Piping & Air Conditioning

with which is merged the Aerologist

Design, Installation, Operation, and Maintenance

Industrial, Commercial, and Large Buildings

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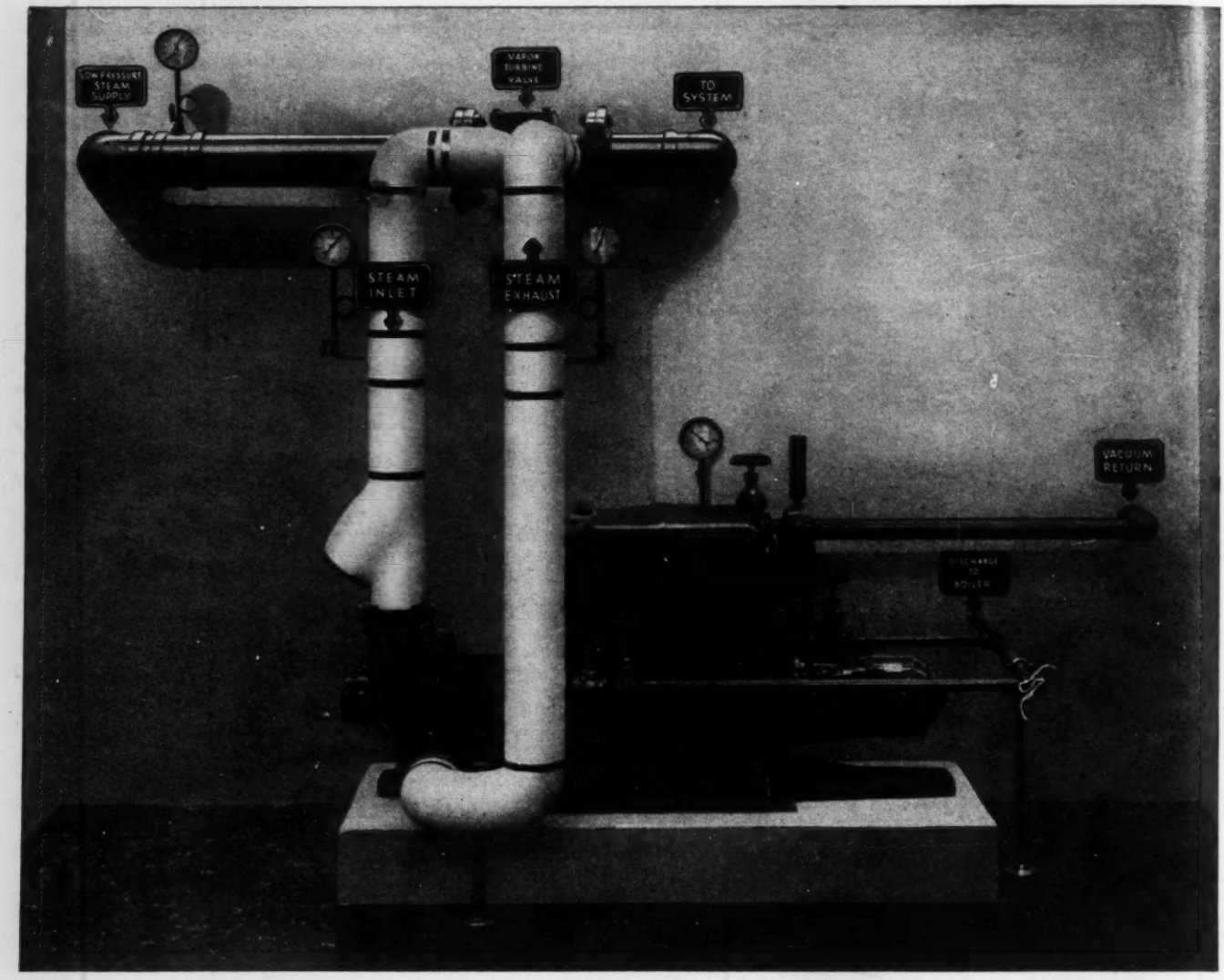
Interrupted Electric Service will not stop this NASH Heating Pump!



In Hospitals, Greenhouses, Schools, Public Buildings, Theatres, wherever heating systems must not fail, install the Nash Vapor Turbine, for it is independent of electric current failure, and continues to operate as long as there is steam in the system.

This is because the prime motive power of this economical pump is a special steam turbine, controlled by a unique "Vapor Turbine Valve", which automatically bypasses from the heating main a small portion of steam, the exact amount necessary to develop the power needed to remove the condensate and maintain the required vacuum on the system. Even this small amount is passed immediately back to the mains, and goes on to the system with little heat loss. This pump operates on any system, high or low pressure.

The Vapor Turbine is a most economical pump, for the elimination of electric current does away with current cost, the largest single item in the operation of an ordinary return line heating pump. Bulletin on request.

THE NASH ENGINEERING COMPANY

205-A WILSON ROAD, SOUTH NORWALK, CONNECTICUT, U. S. A.

How to Determine Cost of Overtime Heat in Industrial Buildings

P. B. Jameson Explains Practical Method for Approximating Cost of Overtime Heat When Tenants Operate Long Wartime Hours

SUMMARY—When tenants of manufacturing buildings operate 24 hr per day, or additional hours than normal, due to the demands of wartime production, it is necessary to determine the additional cost of heating their premises. There are many methods of arriving at the answer. . . . Mr. Jameson, treasurer of the Massachusetts Cities Realty Co. (stores, offices, manufacturing space, and warehouses), explains in detail here the steps in a practical method for determining the approximate cost of such heating service.

THE PROBLEM of determining the approximate cost of overtime heat in industrial buildings divides itself into six definite steps, as follows:

1) Determine from records the cost per cu ft per yr for heating the building, and separate this, if possible, into fuel cost and labor cost.

2) Determine the increased cost per cu ft per yr for night heat with no additional labor and with additional labor.

3) Determine the cost per degree day for heating the building during the regular or normal heating hours and from that determine the additional cost for night heat, with additional labor and with no additional labor.

4) Determine the average or weighted cost per degree day for the specific kind of extra hours. For example, if heat is to be furnished seven days per week instead of a normal six, there is one day of daytime heat, and if night heat is to be furnished six nights, there are six days of night heat and the weighted average would be

$$\frac{1 \times \text{day cost} + 6 \times \text{night cost}}{7}$$

5) Apply following simple formula: Cost = [(Degree Days for Period × Average Weighted Cost per Degree Day) ÷ (Normal Heating Hours for Period)] × (Overtime Hours Furnished for Period).

The degree days may be obtained from the newspapers or the Weather Bureau (form 1030). Inasmuch as the method is based on averages, probably the best method is to use the normal degree days for the month in question as obtained from the Weather Bureau.

6) The last step is to prorate the extra cost for heating the building during overtime hours among the tenants taking advantage of the additional heat, in accordance with the cu ft content of space occupied by each tenant. If ceiling height is constant, cost may be prorated in accordance with sq ft of floor space occupied.

Example of Method

This method may be clarified by taking an actual case which covers most of the possibilities.

Let us suppose that our building has a heated volume of 2,000,000 cu ft and that the total cost of heating, based on last year (with a reasonable allowance for rising labor, material, and fuel prices) was—from our records—$10,000 ($6000 for fuel and $4000 for labor). This cost is for heating the building to 70 F for about 12 hr per day, 5½ days per week, it being customary to shut down the heat nights and week ends. Also, due to the fact that it is a hot water system and comes up slowly, it is necessary to have two 12 hr shifts of firemen during the coldest months even for normal operation. In other words, during October, November, April, and May, only one shift is needed for normal operation, but during December, January, February, and March, two shifts are needed for normal operation.

Now, four tenants (*A*, *B*, *C*, and *D*) engaged in war work and occupying 36,000, 36,000, 12,000 and 6000 sq ft, respectively, desire to work 24 hr per day, seven days per week. The question is, How much shall each tenant be charged for the extra heat?

Let us apply the above described method:

Step 1. Cost per Cu Ft for Normal Day Heat

$10,000 ÷ 2,000,000 cu ft = ½c, or 5 mills per cu ft per yr cost for normal or daytime heat. This is divided 4/10 for labor, or $0.002 per cu ft per yr, and 6/10 for fuel, or $0.003 per cu ft per yr.

Step 2. Cost per Cu Ft for Night Heat, With and Without Additional Labor

Assuming that lowering the temperature during the night in a building will not save more than a maximum of 25 per cent of the fuel consumption, due to the large input of heat necessary to bring up the building temperature in the morning, we may reason that to carry heat all night will take only 25 per cent more fuel than for what we call normal or daytime heating. Assuming this to be the case, the increased cost for night heat with no additional labor required would be:

$0.003 × 1.25	= $0.00375
$0.002 × 1	= $0.002
Total cost	= $0.00575
Normal cost included in rent	= $0.005
Increased cost	= $0.00075

For round figures, let us call the increased cost $0.001 per cu ft per

yr for night heat with no additional labor.

Now, as we know, during four months additional labor is required; then the increased cost for night heat would be:

$$\begin{aligned} \$0.003 \times 1.25 &= \$0.00375 \\ \$0.002 \times 2 &= \$0.004 \\ \text{Total cost} &= \$0.00775 \\ \text{Normal cost included in rent} &= \$0.005 \\ \text{Increased cost} &= \$0.00275 \end{aligned}$$

For round figures, let us call the increased cost $0.003 per cu ft per yr for night heat with additional labor.

Step 3. Cost per Degree Day

If the normal heating season contains 6000 degree days, we may find the degree day cost for the various types of heat as follows:

$$\frac{2{,}000{,}000 \times 0.005}{6000} = \$1.67 \text{ per degree day for daytime heat.}$$

$$\frac{2{,}000{,}000 \times 0.001}{6000} = \$0.333 \text{ per degree day for night heat with no additional labor.}$$

$$\frac{2{,}000{,}000 \times 0.003}{6000} = \$1.00 \text{ per degree day for night heat with additional labor.}$$

Step 4. Weighted Average Cost per Degree Day

Normal heat is six days per week, 12 hr per day. Therefore, seven day heat, 24 hr per day, would cost additional:

$$\begin{aligned} 1 \text{ day} \times \$1.67 &= \$1.67 \text{ (Sunday daytime heat).} \\ 7 \text{ days} \times \$0.333 &= \$2.33 \text{ (Night heat with no add'l labor).} \\ &\$4.00 \text{ (Total extra per week).} \end{aligned}$$

$4.00 ÷ 7 = $0.57 average weighted cost per degree day with no additional night labor. This would apply to the months of December, January, February, and March, when two shifts are normal operation.

Now, for October, November, April, and May, when an additional shift must be added to give night heat, the average cost would be:

$$\begin{aligned} 1 \text{ day} \times \$1.67 &= \$1.67 \\ 7 \text{ days} \times \$1.00 &= \$7.00 \\ \text{Total} &= \$8.67 \end{aligned}$$

$8.67 ÷ 7 = $1.24, average weighted cost per degree day with additional night labor.

Step 5. Formula

Substituting in the simple formula given in paragraph No. 5 at the beginning of this article, and using the month of October for which the normal degree days are found to be 353, and for which additional labor is required at night, the additional degree day cost being $1.24, as determined above, we have:

[(353 degree days × $1.24) ÷ (12 hr per day × 5½ days per week × 4⅓ weeks per month)] × (12 hr per night × 7 nights per week × 4⅓ weeks per month) = $557 additional cost for month of October.

Note: The *additional* daytime heat on Sunday has been taken care of by getting the weighted average degree day cost in step No. 4. We really should have included one-half day for Saturday afternoon in arriving at our average degree day cost, but inasmuch as we let down at that time to clean fires, punch tubes, etc., we do not think it right to include an additional charge for Saturday p.m.

Substituting in the same formula for January, which has 1150 degree days normally, no additional labor being required and degree day cost therefore being $0.57, we find $835 as the additional cost for this month.

Step 6. Prorate Cost

Tenant	Sq ft of space	October	January
A	36,000	$\frac{36}{90} \times \$557 = \$223$	$\frac{36}{90} \times \$835 = \$334$
B	36,000	$\frac{36}{90} \times \$557 = \$223$	$\frac{36}{90} \times \$835 = \$334$
C	12,000	$\frac{12}{90} \times \$557 = \$\ 74$	$\frac{12}{90} \times \$835 = \$112$
D	6,000	$\frac{6}{90} \times \$557 = \$\ 37$	$\frac{6}{90} \times \$835 = \$\ 55$
	90,000	$557	$835

Increased Cost for Shorter Periods

Our method is based on averages for an entire year, and naturally it works out more accurately for an extended period—shorter periods should and would cost more.

For example, even for a long period it would appear reasonable to add 10 per cent to our calculated costs to cover such items as overhead, supervision, depreciation on equipment or profit (whatever you want to call it), for it stands to reason if you use your equipment twice as hard it will not last as long and, therefore, some additional compensation is due.

Again, if heat were furnished for four or five hours only each day, say from 5 to 10 p.m., naturally it would not pay to put on another labor shift for such short hours; so overtime would have to be paid regular men at time and one-half. Therefore, we would suggest that for such regular but short hours per day, at least 50 per cent should be added to the cost determined by the formula.

Also, if overtime is required for one day only, our figures are, of course, much too low and we would suggest doubling the cost found by the formula.

From the foregoing it may at first appear that our method is somewhat complicated and involved, but this is only because we have tried to make it so general as to cover a majority of possibilities. Actually, given a set of conditions, the degree day cost can be quickly determined and then substituted in the formula.

Get Your Scrap in the Fight!

Salvage for Victory

Many Problems to Be Solved in Heating and Ventilating MILITARY AIRCRAFT

By Albert A. Arnhym

SUMMARY—Heating and ventilating of airplane cabins, particularly those of the military type, are compared with air conditioning of ground structures by Mr. Arnhym, who is chief engineer of Pacific-Airmax Corp. As an important phase of airplane comfortization—the provision of essential comforts for military flight crews—heating and ventilating have become major problems of aircraft design due to the extremely high altitudes, air speeds, and low temperatures experienced in military flying. Heat must also be furnished for accessories, anticing, etc., and the various problems resulting from these requirements are discussed. It is suggested that the air conditioning engineer adapt himself to the conditions prevailing on a cabin which moves through thin and cold air at great speeds since he is well qualified to find satisfactory answers to the manifold problems which are encountered.

COMFORTIZATION is a new term which was chosen to designate the art of eliminating or minimizing the discomforts inherent to travel in airplanes, and of creating such comforts as are the rule on comparable ground conveyances.

To many people, air conditioning is synonymous with air cooling, although the field of air conditioning pertains to all of the many problems connected with the provision of sufficient and clean air at comfortable temperatures and humidity. By the same token, heating and ventilating of aircraft cabins is only one phase of comfortization and, therefore, the term "aircraft air conditioning" would not at all comprise the multitude of comforts which must be provided to permit physical existence at great altitudes and low temperatures.

Scope of Comfortization

In some respects the scope of comfortization is narrower than that of air conditioning. For reasons to be explained later, control of humidity within the airplane cabin is usually not necessary. Filtering of ventilating air at high altitude is rarely required, which applies equally to cooling. This leaves only the problems of supplying sufficient fresh air and heat.

On the other hand, the manifold limitations of weight, space, electric current, fuel, and servicing requirements make the supply of air and heat on an airplane so dependent upon other equipment that a complex problem of closely interwoven and interdependent comfort devices results which can be solved only by considering all of them as components of one single accessory group, namely, that of comfortization.

Thus, the heat requirements depend, to a very large extent, upon the amount of soundproofing provided on the thin, metal skin of the fuselage since, for obvious reasons, the soundproofing installation must be equally suitable for heat insulation. This automatically places the heating and sound engineer in the same group.

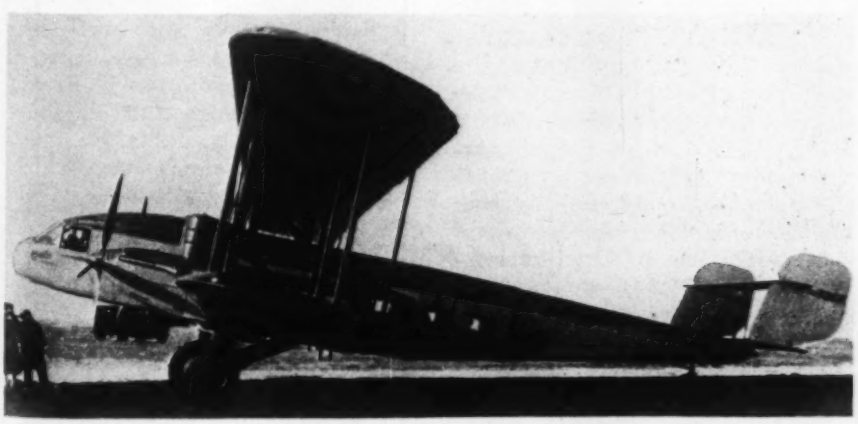
Furthermore, heat must be provided not only for cabin heating but also for warm water supply, which, in turn, is an integral part of the plumbing system. The latter includes lavatories and the galley which requires, in addition to water, practical and efficient means of heat supply for cooking purposes. This adds still more specialists to the comfortization group.

The stylist is another member of this group inasmuch as the interior lining, rugs, and design of windows are of the greatest concern to the heating and soundproofing engineers. This is also true for the location and construction of seats and berths and, subsequently, the disposition of lighting fixtures. Under these circumstances, the above enumerated comfort items cannot be very well treated individually as would usually be the case in air conditioning a ground structure, and heating and ventilating must be considered in this light.

Heating and Ventilating as a Phase of Comfortization

The calculation of the heating and ventilating requirements of, for instance, an auditorium is not at all difficult for the experienced engineer. Conventional methods, wellknown formulas, and numerous empirical data provide the tools which can be used in practically all cases. Very few of these tools, however, are available to the comfortization engineer. In addition, the restrictions which are imposed on him are such that he must forego the use of conventional equipment in most cases and start from scratch.

This applies, particularly, to the heating and ventilating installation. The rigid limitations in weight alone require not only redesign of the apparatus used on the ground but, in many instances,



The 18 passenger Curtiss-Wright Condor of 1930, one of the first commercial air transports to be provided with heating, ventilating, and soundproofing

application of entirely new principles. Even the basic design methods must be radically modified or changed to cope with such new problems as extremely low air densities, pressures, and temperatures, as well as high air speeds. Further difficulties are added by the fact that the values for densities, etc., apart from being far beyond conventional limits, may vary over a very large scale in maneuvering between sea level and altitudes ranging high into the stratosphere.

The greatest handicap of all, however, have been the circumstances under which the heating and ventilating engineer had to make his entrance into the airplane field. Heating and ventilating, like practically all other comfort items, were not considered important enough for aircraft performance to sacrifice weight and space which could be used to greater advantage to improve the flying qualities. Not until the commercial airlines became interested in attracting regular passengers who flew not for the thrill of it but in order to save time, was the value of comfortization recognized.

Stephen Zand, commissioned to investigate the various discomforts which kept prospective customers from using air travel regularly, found lack of proper heating and ventilating to be a most objectionable discomfort—as almost unanimously expressed by passengers and crew members alike. On the basis of these studies Zand, in cooperation with George Page, designed both a soundproofing and "heat and vent" installation for the 18 passenger Curtiss-Wright Condor, which was then (1930) the only passenger plane thus equipped. From that time to this day, the art of comfortization has been improved and augmented rapidly.

Yet, while the airline operators began to realize that comfort was not a luxury but an essential factor from the standpoint of profitable operation, the comfortization engineer was not considered an equal member on the design staffs of the airframe manufacturers. He was called in after the plane was all but completed and had to take whatever space and weight was left to him. Particularly in connection with heating and ventilating systems, the correct placing of ducts and outlets, disposition of heaters and controls, etc., was often practically impossible. It is only comparatively recently that these contingencies are being considered during the design stage, which permits a lighter, more efficient and practical installation by accepting comfortization with all its features as an integral phase of airplane design.

Commercial Vs. Military Comfortization

While an increasing amount of weight and space was expended to create complete comfort for passengers, it was at first not believed necessary to include similar facilities for flight crews. However, once it became evident that physical comfort would greatly improve the efficiency and dependability of crew members, all such comforts were provided for them as were deemed helpful for this purpose and would thus benefit the safety and welfare of the passengers.

Similar considerations prevail in selecting comfort equipment for flight crews of military aircraft. Offhand, it would seem unnecessary and even ridiculous to spend any weight at all for heaters, comfortable seats, bunks, soundproofing installations, galleys, and similar comforts, since military flight crews consist of healthy, young soldiers who have been carefully selected for their physical qualifications. On the other hand, the strain of military flying is such as to tax even the strongest body to the limit. In a series of articles on the comfortization of military aircraft [Aero Digest, June, August, October, November, and December, 1942], the author discussed the effects of flying at great altitudes, low temperatures, extreme noise and low humidity, as well as of the rapid changes of attitude, altitude, and speeds necessitated by military flying. It was shown that no sacrifices are too great, not even those affecting the flying and fighting qualities of a plane, in order to provide a minimum of essential comfort. Lack of air, extreme cold. lengthy exposure to unbearable noise, insufficient lighting, and other discomforts will affect the healthiest and strongest person so much that efficient performance of the vital and difficult duties of a military flyer becomes seriously impaired if not impossible. For this reason, the comfortization of military airplanes is decidedly more than a mere convenience for their crews and important enough to warrant the closest attention.

Among military comfort items, air and heat supply are by far the most vital. Maneuvering at great altitudes where the air is not only too thin but also too cold for existence makes it necessary to provide means for the sustenance of human life which must meet innumerable requirements, such as protection against enemy fire. A shattered oxygen bottle or a badly riddled supercharged cabin, carbon monoxide streaming from a damaged exhaust heater into the cabin, or high pressure steam flowing out of a broken pipe may easily result in the loss of the entire plane with its crew. By making the plane dependent upon this equipment, it must be designed and located in a manner which will not increase the vulnerability of the plane and be able to take a reasonable amount of punishment without failure. This is the more important since the military plane can neither drop to safer altitudes nor make emergency landings such as the civilian plane can.

The need for attaining very great altitudes and flying in even the most unfavorable weather conditions has recently added another task for the heating equipment. For instance, de-icing (removal of existing ice formation) must be replaced by anti-icing (prevention of ice formation), since conventional de-icers, such as rubber boots along the leading edges of wings and control surfaces, do not suffice at very low temperatures and heated air must be passed through ducts in the leading edges instead. By the same token, defrosting of windshields, portholes, sights, etc., must be replaced by antifrosting which, again, is accomplished by heat supply.

Gun breeches, batteries, photographic equipment, and other devices must be kept above freezing temperatures lest they become ineffective or inoperative. Thus, the scope of heat supply on a military

airplane has grown beyond that of comfortization alone and made the heating equipment one of the most important contributors to the overall performance of aircraft, particularly with respect to altitude operation, range, and fire power.

Problems of Military Comfortization

It is evident that the problems of military comfortization are considerably more complex and difficult than those on commercial airliners, let alone ground conveyances. Considering first the general limitations imposed on the designer of heating and ventilating equipment for military planes, that of weight is of course the most serious. Operators of commercial airlines have found that each pound of weight spent for accessories represents a loss in revenue from freight and passengers of $90 a year. Multiplying this by the hundreds of pounds required for comfort equipment and by the number of ships operated, a staggering figure results, which is vivid proof of the importance progressive airlines place on comfortization.

For the military plane there is no problem of loss in revenue. However, each pound of added weight means either less speed, climbing rate, altitude, and range or that much less armament, ammunition, or bombs. Since all of these factors combined determine the military value of a plane, every ounce of equipment which does not contribute to the flying or fighting properties of the plane is essentially wasted. Although necessary comfort devices add indirectly to these properties by increasing the efficiency of the crew, their weight can be only a small fraction of comparable ground equipment, stressing the ingenuity of designers to the utmost. This is further aggravated by the fact that light weight materials such as aluminum and magnesium are so critical that their use must be avoided, and that plastics can be employed to only a limited degree.

Interior of the Curtiss-Wright Condor. Note air duct at bulkhead

Another limitation is that of size. The small space available must be reserved for military equipment, controls, and movement of the flight crew through the plane. Ducting has to be avoided save in transports, ambulance planes, or large bombers. Outlets cannot be placed near parts or apparatus which would be adversely affected by heat. Above all, blowers, motors, ducts, heaters, and similar equipment must be as small as possible and yet permit easy accessibility and servicing.

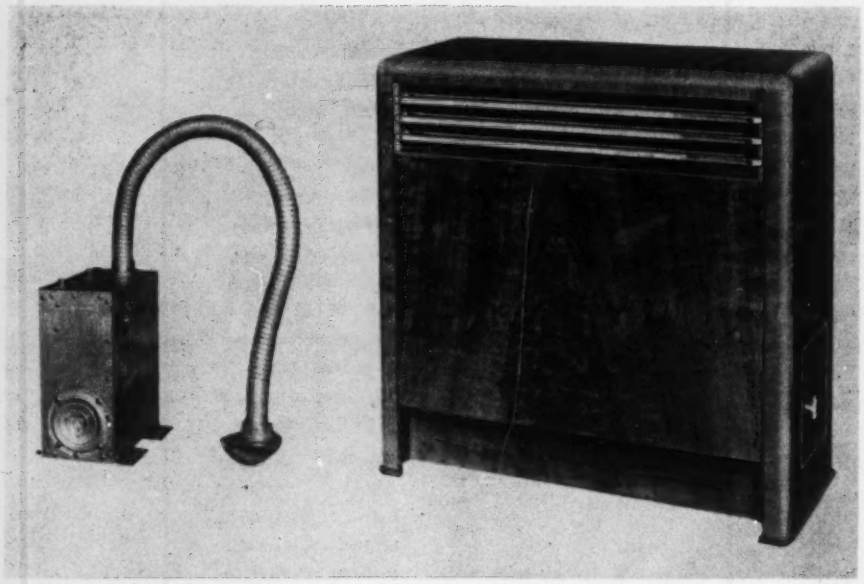
A further limitation which requires no explanation is that of the lowest possible consumption of electric current. The conventional airplane voltage of 24 volts d-c requires high currents for blower motors and controls which must be supplied by batteries. Thus, every ampere of current consumed requires more weight for batteries, lines, etc., and must be reduced to the absolute minimum. This applies equally to fuel consumption for internal combustion heaters, which can be kept down only by the greatest possible efficiency of combustion and heat transfer.

While these limitations are essentially problems of design which could be equally applied to ground air conditioning equipment, many other problems are entirely incidental to aircraft. Foremost among them are those created by flying at great altitudes. There are, specifically, three factors which complicate the design of equipment for operation at high altitudes—the low limits of humidity, air density, and temperatures.

The average moisture content of the atmosphere drops sharply with increasing altitude. At about 35,000 ft the percentage of water in the air becomes practically zero. While at the altitudes at which commercial airliners travel, the lack of moisture is not great enough to be felt as a discomfort, military airplanes are compelled to fly high enough to keep out of the range of anti-aircraft fire or to outmaneuver enemy pursuits. At these altitudes excessive low humidity is not only a serious discomfort but—with low temperature—may result in dangerous moisture condensation on windshields, portholes, and sights when dropping from high to lower altitudes.

It has been seriously considered to carry water along for humidification or, since this would add very much weight, to utilize the moisture in the exhaust gasses. For military purposes none of these schemes warrant the necessary addition of weight, space, and complications, and scientific control of humidification on aircraft must therefore remain a desirable feature for postwar luxury liners. The more important problem of frosting and condensation, however, is being successfully met by heating the affected areas wherever necessary.

Low air density at great eleva-



Heater for military aircraft (left) and ground space heater. Each has a heat output of approximately 25,000 Btu per hr

tions is the main source of complications. At 35,000 ft the density is only a third of that at sea level and does not permit existence of human life unless special means are provided in order to furnish the oxygen necessary for breathing. These means may consist of oxygen supply carried in bottles or tanks, or in making the cabin airtight and using a supercharger to introduce fresh air at sufficient pressure and volume. For military purposes the latter method has the disadvantage of rendering plane and crew very vulnerable, inasmuch as bullet and shell holes in the skin of the fuselage could easily make the supercharger useless. An advantage of this method over the first one, however, is the fact that not only the air supply but also its pressure is commensurate with human requirements.

Flying at great altitudes is exactly the opposite of diving into great depths of water. The pressure within the body does not balance the outside pressure any more which results in discomfort, and beyond certain limits in severe injury, particularly if the pressure changes are very rapid, as is the case in military flying. Thus supercharging is the ultimate solution for high altitude flying although it is not probable that it will be sufficiently perfected in time to be universally used during this war. This is equally true for such proposed schemes as pressure suits or harnesses similar to those worn by deep sea divers.

Low air densities also aggravate the design of the heating plant. Ducting, back pressures, scoops, etc., must be calculated for constant mass flow at all altitudes. Heaters of the internal combustion type require special altitude controls and supercharging for the supply of combustion air. Electrical equipment must be thoroughly tested for conditions at various elevations, since break down voltages, capacities, and insulating values are entirely different from what they are on the ground. Heat loss factors at these altitudes and the air speeds of modern military planes are still a mystery and cannot very well be determined by ground tests. This applies also to the flow of rarified air through ducting and obstructions, and only the gradually increasing amount of data collected through actual experience will help to furnish the answers to most of these questions.

The low temperatures encountered at high altitudes account for many additional problems. Both winter and summer temperatures become not only alike at about 45,000 ft but remain constant from there on. The minimum temperature of —67 F has been made the basis of design requirements, although military flyers have frequently experienced temperatures of much less even at lower altitudes. It goes without saying that designing equipment to work efficiently at such temperatures is quite a task which is not exactly facilitated by the fact that the ranges between upper and lower limits of temperatures, as well as air densities, humidity, etc., are far greater and subject to much more rapid change than those on which ground air conditioning is based.

Military Requirements of Comfortization

In addition to the limitations and requirements necessary for aircraft heating and ventilating equipment, there are those pertaining to military considerations. As pointed out before, vulnerability of accessories, once they are adjudged important enough for use on military aircraft, must be decreased to a minimum without addition of weight. By the same token, damage to comfortization equipment should never result in endangering other functions of the airplane or the health of its crew.

The entire equipment must be absolutely foolproof. Considering the fact that military flight crews consist of young men who, but a short while ago, knew little or nothing about airplanes and their intricate mechanisms, their training should not be still more complicated by requiring lengthy study of the principles of operating and servicing of the heating and ventilating equipment. The physical and emotional strain to which these men are exposed during combat as well as on long scouting and bombing missions does not always permit them to follow carefully prepared operating instructions. For these reasons, no accidental error in handling this equipment should have detrimental consequences.

Ease and simplicity of servicing and repairs is another prerequisite. Service in the field by men of little experience who may lack proper tools and, often, the time required for essential repairs or overhaul is an important consideration of design. Similarly, controls must be as simple as possible and, if automatic, must operate under any and all conditions of military flying. Furthermore, the design must take into account the tremendous stresses and gravitational forces resulting from military flight evolutions as, for example, dive bombing.

RATIONING FUEL OIL FOR COMMERCIAL BUILDINGS

Lewis W. Mauger Reviews the Rationing Program as It Affects Business Properties, Expresses Hope That Plant Efficiency Prior to Rationing Will Be Given Consideration

SUMMARY—The success of a rationing program involving such an essential commodity as fuel oil depends not only upon complete and authoritative data of an engineering nature, but also upon widespread knowledge of the reasons for and objectives of the rationing, and constructive comment on and criticism of the progress being made. Last month, a statement by Joel Dean, director of the OPA fuel rationing division, explained why fuel oil for residences is being rationed as it is. This month, Mr. Mauger (of Brown, Wheelock, Harris, Stevens, Inc., a real estate management firm which has reduced its oil consumption 95 per cent through conversion), reviews oil rationing for business properties. . . . An important point in his article, especially if other fuels are to be rationed, is his plea that the heating efficiency of the building prior to rationing be considered; without such an allowance, a premium is placed on former inefficiency and waste. This same hope was expressed in an article by Eph. A. Tyler in the September, 1942, HPAC, where it was suggested that the maximum fuel allowance for space heating of office, loft, institutional, apartment, and public buildings be the equivalent of 0.6 pounds of steam per 1000 cubic feet of building volume per degree day

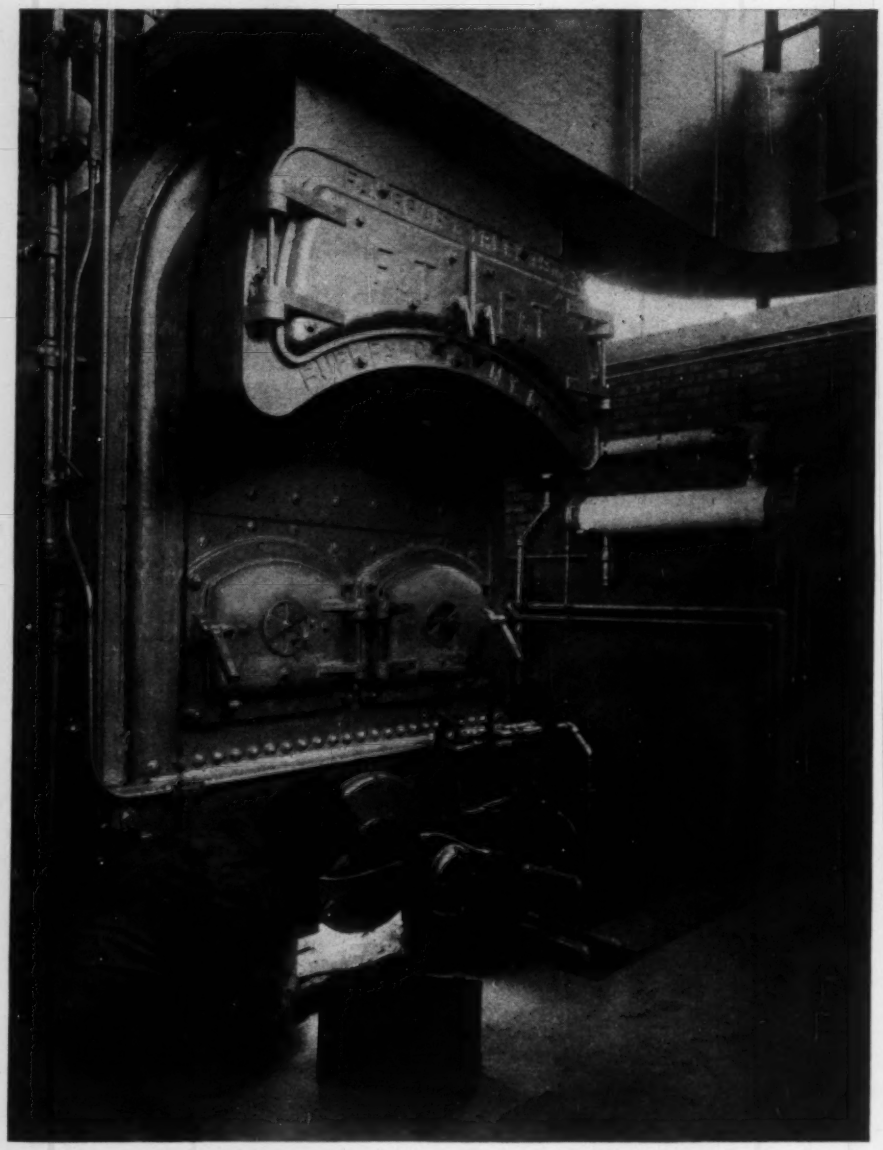
IN THE spring and summer of 1941 it became apparent that a shortage of petroleum products might develop sooner or later on the Atlantic seaboard. Practically all of the gasoline, kerosene, fuel oil, and other refined products and byproducts, as well as crude oil for refineries in the district, were then transported by tanker, which was the cheapest and most practical means. When tankers began to be removed from the runs from the Gulf ports it became impossible to maintain the supply at the consumption rate and the deficiency had to be made up from the tremendous stocks in the area.

A few building managers became sufficiently concerned at that time to study the possibilities of obtaining heat or power from some other source than fuel oil in the event that a serious scarcity should develop. For some boilers, materials were purchased and stored so that quick conversions could be made if necessary during the ensuing winter. Some grate bars purchased were of the permanent conversion type, but more frequently stationary grates that could be placed in the oil burning firebox without disturbing more than a few courses of firebrick lining were preferred. The conversions were looked upon as temporary, to be made only for short periods when the shortage of fuel oil might be severe, with a return to oil expected as soon as the stringency cleared. These precautions proved unnecessary that year, although there were days when the oil supply was extremely limited.

Early in 1942 the submarines began to take a serious toll of coastwise tankers, reducing the supplies in New York and other harbors to the danger point, and convincing many owners that it was no longer safe to rely on an unlimited and uninterrupted supply of fuel oil. Conversion began to be looked upon as the only means of guaranteeing an adequate supply of heat and hot water to tenants for the next heating season, and contracts for grates, stokers, and district steam service were signed by the more cautious managers. A further spur to conversion was the issuance of limitation order L-56, which gave the WPB director of industry operations the authority to demand conversion under penalty of denial of further deliveries, and required the use of facilities using unrestricted fuel to the full capacity of such facilities. This order was amended in May, reducing the delivery of fuel oil for space heating and hot water requirements to 50 per cent of the deliveries made during the corresponding month of 1941 to any building or plant. This curtailment made it impossible for many buildings to provide normal hot water for tenants last summer, and, although the amount of oil saved was only a small proportion of the annual demand, it undoubtedly convinced many owners that steps should be taken toward conversion.

In September, restrictions were relaxed to permit tanks to be filled prior to the heating season, and rationing became effective October 1, 1942, with the inventory being considered as a part of the ration. Rations for buildings other than private dwellings were set at two-thirds of the consumption for the 12 months ended last June, adjusted for the normal degree days in any district. For New York City the ration as adjusted was about 74 per cent of the previous use. By changing the value of the coupons, the ration for the third heating period has been reduced to 90 per cent of the original amount granted, and for other than residential properties another cut of 25 per cent has been made.

No third period rations were supposed to be issued for other than private residences unless proof were submitted and substantiated by the Petroleum Administration for War to the effect that the building was not convertible. A yardstick of three dollars conversion cost for each barrel of oil saved has been used to determine whether the cost of conversion is reasonable, but no consideration is given to the increase in operating costs or the inconvenience caused by the use of coal. Even if coal must be stored outside of a building, and if the boiler does not have sufficient capacity to carry peak loads, buildings have been ruled to be con-



It is hoped that a suitable formula may be developed to allow for heating efficiency prior to rationing fuel for commercial properties. Without such allowance, the effect is to place a premium on previous inefficiency. (Checking combustion and draft should be routine practice in order to operate efficiently)

vertible so long as it is physically possible to convert and the necessary materials are available.

No Allowance for Efficiency

In issuing rations no provision has been made for granting a higher ration to an efficient plant than to an extravagant one, except for the limitation provisions for private residences. The inequity of requiring all buildings of similar occupancy to reduce consumption by the same percentage, irrespective of relative efficiency, has been drawn to the attention of federal and local officials, but no relief has been granted. Perhaps this is because of the lack of a workable formula that would meet the general approval of heating experts, but the effect has been to place a premium on previous inefficiency by granting a ration that would provide satisfactory heat if the operation could be sufficiently improved. It may be that the appeal boards may be authorized to take the prior efficiency into consideration, but no such announcement has been made. It is hoped that before coal or street steam is rationed (if they are to be rationed), a suitable formula may be developed to overcome this difficulty.

Conflicting Viewpoints

A definite and dangerous fuel oil shortage has now developed. The contradictory publicity that has been given to the fuel oil situation may be responsible for much of the present difficulty, since the public was not definitely advised as to the actual seriousness of the outlook. Often, in the same newspaper, there would appear a statement by the Petroleum Coordinator's office which presented a pessimistic view, and another item—quoting, possibly, a witness before a Congressional committee — implying that the problem would be easily solved by American genius. Again, there would be published an estimate of the amount of oil the rails might be expected to move as compared with the demand, accompanied by another statement of the steps being taken to construct oil pipe lines so written that the layman would be apt to discount the deficiency which the first figures showed. The representatives of the OPC were unanimous in presenting the darker side, in spite of the fact that by their efforts they were taking oil business away from the companies for which they formerly worked. But the public was inclined to consider that it was the job of this agency to induce people to convert, and their warnings were too often taken as unnecessary cries of "wolf."

Similarly, no definite guidance appeared as to the ration that might be allowed during the heating season, until after the heating season began. The allowance last summer was 50 per cent, and speculation as to heating rations varied from 50 to 90 per cent—with the majority guessing between 65 and 75. A ration as low as the present one for business properties was not thought of. Even in October opinion of officials was divided on the probability that oil would be denied to plants that could change to another source of heat. Perhaps the confusion was inevitable because of the magnitude of the problem and the number of factors involved, and perhaps public opinion had to take the sad news of the probable failure of the unlimited oil supply in gradual doses. But it does seem that a more graphic painting of the true picture might have convinced many more building

operators of the necessity for conversion.

Division of Authority

There has also been a confusing division of authority between the various agencies having to do with petroleum, which have included the Office of the Petroleum Coordinator for War (now the Petroleum Administration for War), the Office of Defense Transportation, the War Production Board, and the Office of Price Administration, represented locally by the War Price and Rationing Boards. In general, the OPC or PAW have (from the public's point of view) been interested in making supplies available where they were most needed, with civilian requirements at the bottom of the list, and in convincing users of the necessity of conversion. PAW engineers will inspect plants to give advice on the possibility of converting, and will issue certifications for any plant for which no means of converting may be found. The ODT controls the movement by rail, truck, and otherwise of petroleum products into a district, the distribution within the district, and the delivery to consumers. The WPB cooperated with OPC by issuing the basic limitation order with its subsequent amendments, and by making materials available for pipe lines, transportation equipment, and conversion equipment. WPB either issued or denied the preference ratings required to obtain some of materials needed for conversion—such as stokers, piping, valves, controls, and wiring. Sometimes the WPB denied ratings for materials on the basis that the materials were of more value than the amount of fuel oil that might be saved through their use, but other agencies may still insist that conversion be made, thus leaving the plant operator between the two millstones.

The OPA, with its volunteer boards, handles all rationing, including the determination and issuance or denial of coupons, and establishing the value of the coupons for the various heating periods. The members of the rationing boards should be congratulated on the unstinted service they have rendered in a thankless job, but they are allowed little discretion in applying the general rules which often do not fit a specific case. Appeals from local board findings may be taken successively to the state, district, and federal officers, but when oil is needed there often is insufficient time to follow such a procedure.

If it were possible to consolidate the functions of these agencies into a single body having comprehensive authority over the entire oil problem, much greater progress might be made and greater general satisfaction produced. Even if this ideal is impossible because of the interlocking of other wartime problems, a single agency handling the contacts with the public would greatly simplify the operator's difficulties. Such an agency should have adequate engineering talent with practical experience in boiler operation for consultation on the feasibility of changing from oil to coal.

Progress in Conversion

A recent survey of apartment buildings on both the east and west sides of New York City showed that much progress had been made toward eliminating the use of oil in these areas. Of a total of 3365 multi-family dwellings between 57th and 96th Sts. in which heat is provided by the landlord, 288 buildings were heated by oil as of January 1, 2927 were heated by coal, 33 had combination plants, 115 were supplied by central station steam, and two burned gas. Other conversions are still being made, and some managers report as high as 95 per cent reduction in fuel oil consumption in the groups of buildings under their control.

Reconversion After War?

There has now arisen a serious shortage of coal in the east due to transportation difficulties, the increase in demand on the part of war industries and converted oil plants, and the strike of the anthracite miners. Pea coal is almost unobtainable, with nut and rice coal very short. Some of the highest grades of bituminous coal, especially in pea size, are disappearing, and oil treatment is becoming a luxury of the past. However, many operators are finding satisfaction with well designed coal plants, particularly those fired by automatic stokers.

There is a feeling that many buildings will not revert to oil after the war. It is possible that, after the war, the supply of bunker oil will be much less than previously due to the progress that has been made in obtaining much higher percentages of gasoline and other more valuable products from crude oil. Derivatives are now being used in the manufacture of many types of materials, and further industrial demands may induce the refiners to keep the residual oil at the lowest possible minimum. This may mean higher prices for the fuel oil that is available, so that there may be little inducement for plants to reconvert. The author, for one, would welcome authoritative information on this point, and I am sure many other operating engineers join me in expressing this wish.

CONTROLLED MATERIALS PLAN REGULATIONS ISSUED

Controlled materials plan regulation No. 1, defining the rights and obligations of industry under CMP, was issued January 12 by the War Production Board. This basic regulation, dealing specifically with methods of applying for, receiving, and making allotments, gives legal standing to procedures outlined in the informational booklet on CMP, published November 2.

For the most part, regulation No. 1 confines itself to spelling out in detail general principles announced in November, and its publication provides manufacturers with what amounts to an operating guide in this field. In some details the regulation departs from the procedures announced in the original publication of the plan and, to this extent, it supersedes the former publication.

CMP regulation No. 2, issued January 7, provides controls over manufacturers' inventories of the controlled materials—aluminum, copper and steel. Other CMP regulations, now in preparation, will cover such phases of the program as the place of preference ratings in CMP; maintenance, repair and operating supplies; construction and facilities; warehouses and other distributors; and reports.

How Should This EXHAUST STEAM WATER HEATER Be Piped?

SUMMARY—A reader of HPAC submits the accompanying sketch of an exhaust steam water heater and its piping connections, and asks for advice on changing the piping to achieve better performance. . . . A contributor analyzes the layout and gives his recommendations, including changing the heater to a single pass rather than a seven pass and substituting a suction tee for the 45 deg fitting

THE EDITOR—

As a subscriber to Heating, Piping & Air Conditioning I would appreciate your advice on the water heating problem as outlined in the accompanying sketch. As shown, the cold water goes into the exhaust steam heater. The heater has seven rows of 2 in. tubes and has baffles which cause the water to make seven passes to get out.

1) I have been told cold water should go into bottom of hot water storage tank. Do you agree with that; if so, why?

2) Would the 2 in. house circulating line give better results if it went into the bottom of the storage tank rather than as shown in the sketch?

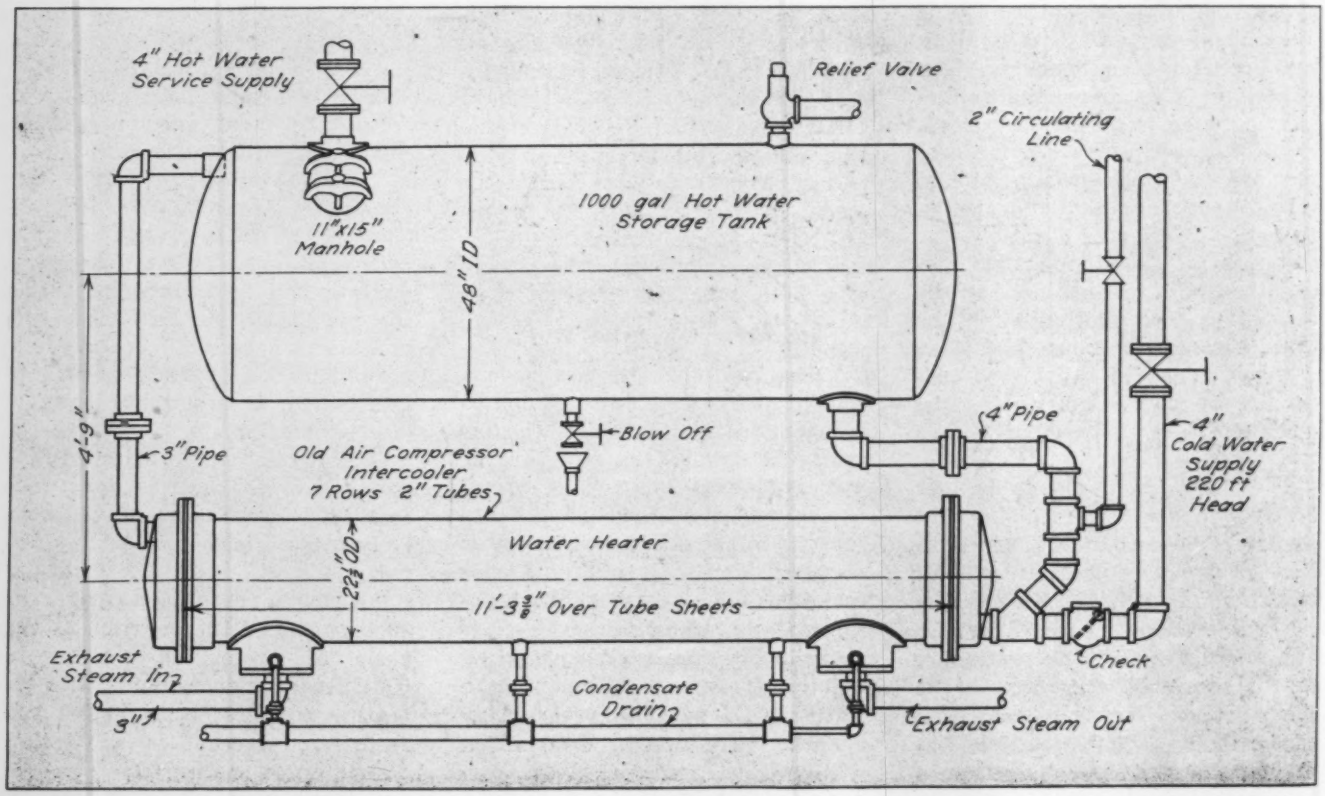
Any help you can give me on the above will be greatly appreciated.—C. F. T.

REPLY—

In answer to your first question, it is necessary to point out that the water, from the time it enters the heater until it leaves, must pass back and forth through the heater seven times. Seven passes offer considerable resistance to gravity circulation. Consequently it is very probable that with your seven pass heater the gravity circulation between the storage tank and the heater is not as rapid as it might be. This means that the contents of the storage tank are heated only when water is being drawn. In other words, the cold supply water passing through the heater seven times emerges at a high enough temperature to heat the water in the storage tank. Consequently, with your present seven pass heater you will probably not get satisfactory results if you connect the cold water into the bottom of the storage tank.

However, there is one objection to your present cold water connection. It is probable that whenever hot water is drawn from the top of the storage tank that all of the cold water entering the system does not pass through the seven pass heater. Instead, part of the water flows through the heater on its way to the storage tank, while the remaining portion—in spite of the 45 deg fitting—flows through the 4 in. circulating return line directly into the bottom of the storage tank.

If you find that during periods of heavy draw the hot water is not

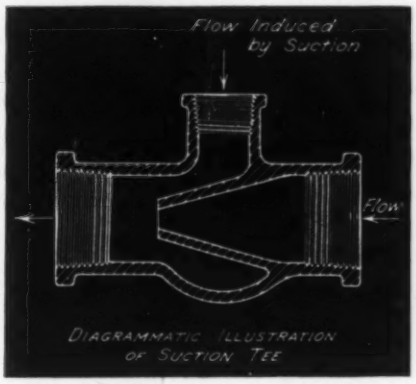


quite warm enough, it may be due to the cold water entering the bottom of the tank directly. If this is the case, the installation of a check valve with a light flap in the vertical portion of the 4 in. line would be desirable. Although a check valve would not completely stop bypassing, it would probably stop enough so that your hot water temperature would be increased—at least during periods of heavy draw. On the other hand, if your present hot water temperatures are satisfactory, there is no need to install the check valve.

If you can possibly remove the baffles and thus change the heater to a single pass—that is, so the water would flow through the heater only once—there would be a very material improvement in the gravity circulation between the heater and the storage tank. In this case, the water in the storage tank could be heated entirely by gravity circulation between the tank and the heater. If the baffles are removed, the cold water connection could be changed to the bottom of the storage tank, although in this case it would not be strictly necessary. If the heater is changed to a single pass and the cold water connection left as at present, it might still be desirable to install a check valve in the vertical portion of the 4 in. circulating line as previously mentioned.

If the cold water supply is left connected to the heater as at present, the installation of a check valve in the 4 in. circulating water line was recommended in the preceding paragraph to prevent the cold water from entering the bottom of the storage tank. For this purpose a suction tee is superior to the use of a check valve. The suction tee should be substituted for the 45 deg fitting now on the cold water line and to which the 4 in. circulating line from the tank is connected. Because of the aspirating effect of this suction tee, there would always be a strong flow of water from the bottom of the tank through the circulating line whenever cold water was flowing through the heater. Furthermore, because of the flow through the 4 in. line, more thorough mixing of the water in the storage tank would take place, thus tending to provide water at a more nearly uniform temperature throughout the tank. The use of the suction tee would be especially desirable if the heater is left as a seven pass as at present, and it would still be desirable even if the heater is converted into a single pass type.

In answer to your second question, if you do substitute a suction tee for the 45 deg fitting, the 2 in. circulating line can be left connected as it is at present. However, if you are unable to obtain the suction tee, it would be desirable for you to connect the 2 in. house circulating return line directly into the bottom of the storage tank. As the 2 in. circulating line is connected at present, it is probable that whenever water is drawn from



DIAGRAMMATIC ILLUSTRATION OF SUCTION TEE

the system, some cold water bypasses the heater, enters the 4 in. pipe, and then flows into the 2 in. circulating line to the point where the water is being drawn. In this way a mixture of hot and cold water is supplied to the point where the water is being drawn. For this reason it may be difficult at times to supply water at a high enough temperature to points which are so located that the distance from the tank to the point along the return circulating line is very much shorter than the distance along the hot water supply line. Although the installation of a check valve in the 2 in. line would be of help, in this particular case a check valve is hardly dependable enough. Either the 2 in. circulating line should be connected into the bottom of the storage tank or the suction tee installed. As previously mentioned, if you do install a suction tee, you can leave the 2 in. circulating line connected as at present and without installing a check valve. In this case, the pull created by the suction tee will be strong enough to insure circulation through the 2 in. return line to the heater at all times.

There is one other matter that should be pointed out in regard to your present hot water supply connection. It would be better if the 4 in. hot water service supply connection and the relief valve connection at the top of the storage tank were interchanged. This would place the 4 in. hot water service supply connection at the opposite end of the tank from the 3 in. circulating connection from the heater. In this way, whenever water is drawn from the storage tank, the cold water passing through the water heater, and heated there, would have to flow the entire length of the hot water storage tank on its way to the 4 in. supply connection. This flow across the tank would cause considerable mixing which, in turn, would mean that the water stored in the tank would be at a more nearly uniform temperature throughout. At present, when hot water is drawn, the heated water entering the tank through the 3 in. supply pipe can pass almost directly to the 4 in. hot water service supply. Because of this, little mixing occurs, and it is probable that the temperature of the water throughout the storage tank varies considerably more than it would if the hot water supply connection were at the opposite end of the tank.—W. G.

AIR CONDITIONING SERVES ELECTRONICS WORKSHOP

A new workshop, hospital-like in cleanliness, with gleaming white machinery and a brilliant ultra-modern lighting system, has been put into operation at the Westinghouse Lamp Division to produce electronic equipment. Protected from the tiniest particles of dust and moisture by air conditioning and other precautions, delicate tubes, such as those for high power radio transmission, are assembled.

In the assembly of vacuum tubes freedom from moisture or dust is of extreme importance. A tiny particle of moisture on a tube part collects grease. Then, when the tube is heated, the grease vaporizes, leaving particles of dirt which may interfere with efficient operation.

Removal of Refrigeration Equipment from Existing Comfort Conditioning Systems for Use in War Production

Important Consideration Is Contribution of Each Application to War Effort, Says Charles S. Leopold . . . Distinction Between "Comfort" and "Industrial" Air Conditioning Is Often Arbitrary

SUMMARY—The plan to remove refrigeration equipment from comfort air conditioning installations for use in synthetic rubber and other war production was reported in the October HPAC, and in November there were three articles presenting information on details, including a discussion of disconnecting, removing, and re-installing the machines. . . . There has been some criticism of the plan on the basis of the government itself using air conditioning in its own offices. Mr. Leopold, consulting engineer and member of HPAC's board of consulting & contributing editors, believes that each installation should be judged on the basis of its direct contribution to the war effort

THE WAR Production Board's plan to transfer refrigeration equipment from existing applications to synthetic rubber plants and other essential war industries has met with varied response.

When the program was explained to a group of department store executives, they then and there unanimously volunteered to sell their equipment. Subsequently, other department stores and other users of refrigeration equipment not represented at the meeting voluntarily offered their equipment.

In contrast, there is a large group who, by word of mouth and through the press, condemn "the government" for daring to ask anyone to sell his equipment while "the government" continues to use refrigeration for air conditioning in Washington. Curiously enough, for the most part this comment is not confined to people now or potentially affected by the program. [As a matter of fact, the WPB has asked for enabling legislation to permit the removal of refrigeration from some government buildings, notable among those the buildings housing a large portion of its own personnel.]

To one who works in the "industrial" and "comfort" (nasty word during a war) fields, statements of this type indicate extreme oversimplification of a very complicated problem.

Obviously, if refrigeration for essential war industry cannot be obtained through regular manufacturing channels, or if the time factor and the material situation justify this procedure, all less essential applications of refrigeration must be sacrificed. Fundamentally, there is little disagreement with this idea but, as usual, the controversy is on detail.

As an attack on this total problem, it would seem logical to list all of the present equipment in the order of its contribution to the immediate war effort and, further, to list the equipment according to its climatic justification. Rating in order of necessity would be somewhat arbitrary, but though faulty it would be far better than a hit or miss basis of selection. Excess capacity and standby equipment everywhere, with few exceptions, should be the first released. Such a list should include buildings and industries not directly contributing to the war effort, as well as comfort installations in war industries and government offices.

The important consideration is the degree to which each application applies to the war effort. Many of the above noted refrigeration applications are of great value in productivity, particularly as regards manpower conservation. It is climate rather than chance that has concentrated our manufacturing industries in the north, and manpower shortage and congestion that are now forcing them south. In the south the potential saving in manpower by conditioning industrial plants, particularly those requiring constant humidity, is not fully appreciated.

The distinction between industrial and comfort air conditioning is in many cases arbitrary. A blackout factory may fall into both categories. An air conditioned drafting room, usually considered as a "comfort" job, frequently is an industrial application.

We do not have a surplus of executive ability. That which we do have must be conserved so that it can be used to the utmost. If anyone believes that our government agencies are comprised of a group of self-indulgent gentlemen, a trip to the WPB, the SOS, or many of the other agencies, would soon dispel the illusion. How shall we evaluate the relative importance of executive time and energy, in Washington and elsewhere, against a given number of tanks, bullets, and planes?

Many office buildings wholly devoted to war work have taken advantage of air conditioning to build large interior spaces. In many cases the occupancy may average as high as one to 45 sq ft, and the lighting requirements may be in excess of 3 watts per sq ft. Without refrigeration, efficient use of this space is, in some locations, not practical throughout a large portion of the summer.

In the foregoing I do not intend to suggest that refrigeration should

not be removed from office buildings but, rather, to indicate that it is an integral part of the total problem.

The air conditioning industry as a whole has made no concerted effort to present the case for air conditioning other than for strictly process work.

An inspection of comparative weather data will show that, assuming the same type of application, refrigeration equipment can be dispensed with in the vicinity of Southern California, Massachusetts, Michigan, Illinois, and New York more easily than in the District of Columbia, Louisiana, or Texas.

Starting with a list of the presently anticipated real refrigeration requirements, and a list of the installed refrigeration, for all purposes, throughout the country, and with due consideration of the factors of relative necessity, building construction, climate, and application, we should have a good start toward the analysis of this complicated problem.

It is to be hoped that the WPB has approached or will approach the problem in this manner as, although the relinquishing of equipment has to date been on a voluntary basis, a statement by the WPB that a certain piece of equipment is needed is practically a command to the average public-spirited citizen.

CENTRAL STATION SUPPLIES STEAM TO INDUSTRIAL PLANT FOR WAR USE

THE EDITOR—

I was interested in the article of the above title published in the January HPAC; the following comments pertain to our own experience with the interchange of steam and power between a utility and an industrial plant:

Ten years ago we contracted for all of the steam necessary for our laboratories and our experience has been so satisfactory that we have renewed the contract for a period of another ten years.

The steam is delivered through a 10 in. line at 225 psi pressure at a temperature of 500 F. We are now taking steam up to 90,000 lb per hr. The steam line, which is approximately 6000 ft long, is in a concrete trench under city streets and has expansion joints every 100 ft. These expansion joints are accessible through manholes in the street.

The steam is all metered through flow meters. The first metering occurs at the central station, the second metering occurs on our premises and it is through these meters that the billing is determined. The third metering occurs as the steam goes into our turbines. There have been no difficulties in calculating the amount of steam being delivered. There have been no interruptions of the service except as planned in advance once or twice per year.

The steam is passed through turbines acting as reducing valves and these turbines are exhausted at 5 psi pressure and bled at the 100 psi stage. The generators are synchronized with the generators of the power company, and when steam uses decrease the power company automatically supplies the additional current needed.

The scheme of operation is not difficult because every hour in the year more electricity is needed than can be generated with the steam being purchased. During the summer months the electricity generated supplies about one-fourth of the total electricity needed. On zero days the steam purchased generates about three-fourths of the electricity needed.

"OPEN FOR DISCUSSION"

Our boiler room has been converted into a chemical manufacturing department, which gives us additional manufacturing capacity.

The condensate is not returned to the central station and is very useful because as condensate it is soft and ideal for cleaning purposes and in addition is hot. All the condensate is used summer and winter and additional hot water must be heated for plant operations. A 40,000 gal storage tank takes care of the fluctuations in usage of the hot condensate.

From a manufacturing standpoint the coal, ashes, dirt from same, and delayed coal shipments now are the problems of someone else. The same is true with boiler and stoker repairs.

The original contract guaranteed a purchase of steam to the extent of $50,000 per yr. Purchases at this time amount to well over this figure.

The power company has enjoyed a very steady income from this contract, which was especially helpful to them in 1932 and the years immediately following. Probably within the next 10 years, when we have the adjustments following the war, they will repeat the experiences just mentioned.—WILLIAM A. HANLEY, Eli Lilly and Co., member of HPAC's board of consulting & contributing editors.

AA-3 RATING FOR WAR HOUSING

A blanket preference rating of AA-3 was assigned January 11 by the War Production Board to deliveries of materials for use in the construction of most of the war housing projects programmed by the National Housing Agency. The action, which makes the up-rating automatic for the builder, affects the war housing for which preference rating orders P-55 have been issued to a builder, or P-19-d and P-19-h have been issued to the Federal Public Housing Authority. The builder, however, is responsible for extending the new rating to his suppliers in accordance with priorities regulation No. 12 of WPB.

In a second provision announced at the same time, all AA-4 ratings assigned by preference orders of the P-19 series, covering essential construction projects, were raised to AA-3.

How to Prevent Oscillations in Large Inertia Fan Drives

E. O. Marty, S. F. Henderson, and F. Richardz Describe Damper for Absorbing Energy to Eliminate Difficulty

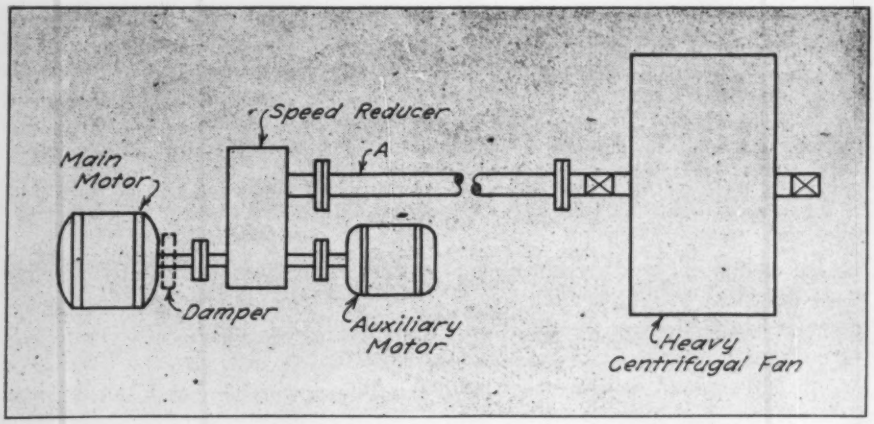


Fig. 1—Schematic diagram of fan drive. The full floating shaft connecting the blower to the speed reducer is about 7 ft long. The torsiograph was belted to point *A*

SUMMARY—Critical oscillations may occur during the accelerating period when driven equipment has exceptionally large inertia; the problem came up in connection with the fan drives for a large ventilation project, and was solved by means of a damper which absorbs the energy added to the system on each oscillation and prevents its storage. This avoids the objectionable buildup in the amplitude of the oscillations. . . . The authors are, respectively, chief mechanical and electrical engineer of the Pennsylvania Turnpike Commission, and motor design engineer and manager, gearing engineering dept., Westinghouse Electric & Mfg. Co.

WITH EXCEPTIONALLY large inertias of the driven equipment, critical oscillations may occur during the accelerating period. On the fan drives in two of the Pennsylvania Turnpike tunnels this condition was prevented by the use of simple dampers employing a new principle.

The fans with the lowest volume requirements—and, therefore, the lowest speed—required a 7:1 ratio speed reducer and motors rated 40 hp at 1170 rpm and 5.5/0.9 hp at 580/280 rpm. The inertia of the fan referred to the motor speed was about 90 times that of the motor and accelerating periods of from 25 to 50 sec were involved.

The operation of such a drive will generally prove to be exceptionally quiet over the entire operating range of speeds except for a small part of the accelerating period, where a peculiar chatter or torsional oscillation may occur. If this condition is observed it is generally proved to be caused by the relationship of the inertia and driving forces. With the 40 hp motors energized, the oscillation became observable at approximately 750 rpm motor speed, reached a peak at or near 900 rpm, and disappeared at 1000 rpm. The oscillations diminished at a much faster rate than they built up and occurred at a rate of about five cycles per sec.

A torsiograph record of this behavior is reproduced in Fig. 2a. From a chart of this type it is possible to determine the amplitude and frequency of oscillation of the floating shaft about its average position. Fig. 3 shows the relationship existing between the motor speed and the amplitude of oscillation.

Explanation of Oscillations

The explanation of these oscillations can be made by a comparison of the fan drive with the flywheel of a watch. With the main spring completely unwound the escapement wheel will oscillate back and forth at its natural frequency when disturbed by an outside torsional force. This movement will continue with decreasing amplitude until the wheel has come to a stop. The period of operation depends upon the initial force and the friction, or damping, present. It is possible to continue the oscillations indefinitely by adding sufficient energy to replace that absorbed by damping if the wheel is regularly struck or hit with the proper timing.

Likewise, the fan drive will oscillate at its natural frequency when disturbed by a torsional force momentarily applied and will continue to oscillate with decreasing amplitude until oscillations disappear. With the unit driven by the motor and operating in the range of 600 to 900 rpm where the motor torque increases with an increase in speed, as shown in Fig. 3, oscillating energy is added to the system. The energy thus added exceeds that absorbed by system damping and the amplitude of oscillation continues to increase. When the amplitude causes the motor speed to alternate between such values that the slope of the speed torque curve changes to give decreasing torque with increasing speed, the oscillating energy is absorbed rather than added and the amplitude decreases rapidly.

A complete treatise of this problem, its study, and solution has been covered in a paper titled Investiga-

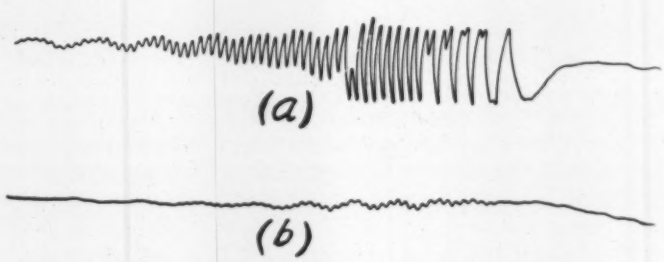


Fig. 2—Torsiograph chart made on one fan unit. The operation before the damper was installed, where maximum double amplitude represents more than 80 mechanical degrees oscillation of the motor rotor, is shown in *a*. At *b* is shown the operation after the damper was installed and here the maximum amplitude is only 6 degrees

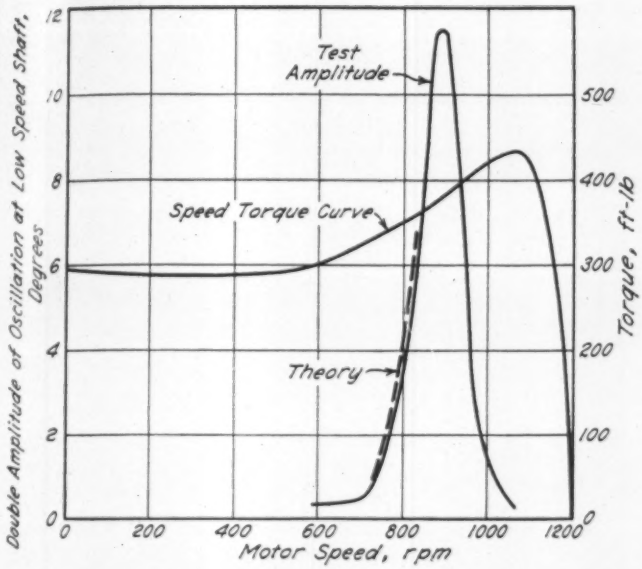


Fig. 3—Amplitude of oscillation. This curve shows the relationship existing between the 40 hp, 1170 rpm motor delivered torque and the amplitude of oscillation before the damper was installed. The amplitude of oscillation shown when multiplied by the gear ratio 7.19 and corrected for backlash gives the oscillation of the motor rotor

tion of Self Excited Torsional Oscillation and Vibration Damper for Induction Motor Drives, by A. M. Wahl and E. G. Fischer, presented at the 1941 annual meeting of the American Society of Mechanical Engineers.

How to Avoid Oscillations

These oscillations may be avoided by either using motors with a different slope of the speed torque curve or by increasing the damping in the system. The several solutions possible are:

1) *Motor Characteristics* — The slope of the speed torque curve may be such as to materially reduce or eliminate the slope where the torque increases with an increase in speed. Three kinds of motors are possible:

a) Wound rotor motor, with a number of accelerating steps of resistance in the rotor circuits arranged by suitable control to always operate on a speed torque curve where the torque decreases as the speed increases. The wound rotor motor and its control is more expensive than the squirrel cage motor and its control.

b) High resistance squirrel cage rotor delivering decreasing torque with increase in speed. This type of motor is less desirable because it is physically larger and has a much lower operating efficiency.

c) A double deck rotor may be used on certain installations, but in many cases the motor speed combination is not favorable to this construction or the accelerating period may be too long and lead to the burning out of the small upper rotor windings.

2) *Mechanical Design*—The dimensional limitations of the floating shafts are usually such that possible variations in length or diameter are small. Thus, the frequency of oscillation may be affected but the effect on the magnitude of stresses imposed will be negligible. The obvious solution becomes that of adding damping to the system. In this category there were two types of dampers considered:

a) Frictional dampers. This type was considered but was discarded in favor of the energy absorber type.

b) Energy absorber. Some method of absorbing the energy added to the system on each oscillation in order to prevent its storage would effectively eliminate the objectionable buildup in the amplitude. The corrective means must be free from influence by temperature, be simple, small, and require no maintenance. Such a device has been developed and effectively provides the desired solution to the problem.

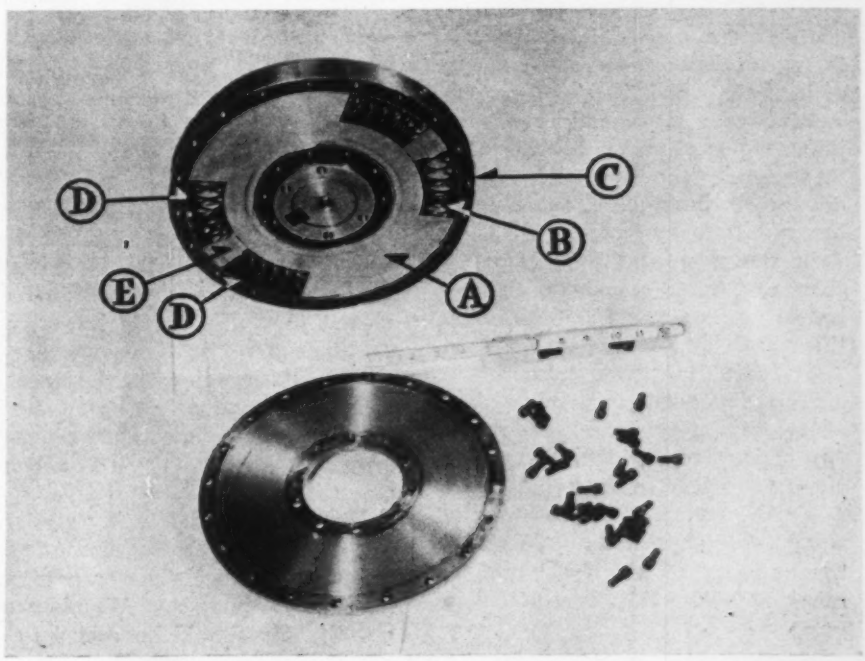
Damper Absorbs Energy

The damper illustrated in Fig. 4 is essentially a small oil pump arranged to force oil from one chamber to another through a restricted passage. The springs are designed to tune the damper to the natural frequency of the fan drive. Thus, a maximum relative motion between the mass and enclosure is obtained, with a small oscillation of the shaft.

The operation of the system during acceleration with the damper in place is quite different from operation without it. The system may oscillate during acceleration, but with the damper properly installed the drive comes up to full speed uniformly and smoothly without any observable oscillation. The chart of Fig. 2b shows the amplitude of oscillation "nipped in the bud" and limited to a value that does not evidence itself to an observer.

Such dampers, permanently sealed, are simple, effective, and in no way affect the operating efficiency of the fan system. One of the most encouraging facts developed in the field tests described is the possibility of predicting satisfactory performance of the damper. Calculation methods are such that little or no "cut and try" field adjusting is necessary to produce satisfactory systems.

Fig. 4—The damper construction. The mass *A* is connected by springs *B* to the outer case *C* that is keyed to the motor shaft. A small oscillation of the motor shaft causes relative motion between the mass and the case, forcing oil back and forth between chambers *D* through orifice *E*. This pumping action absorbs energy



Practical Application of Recent Developments in Theory to Air Conditioning Design Problems

William Goodman Assembles Basic Facts and Tells Their Significance in Simple Language

SUMMARY—Developments in the theory of air conditioning in recent years have made it possible to design practical air conditioning systems on a more rational basis than has hitherto been the case. Rational methods of design result in more nearly correct and suitably sized air conditioning systems. An incidental, but today equally important, result is the fact that rationally designed systems may also be economical ones. For example, air volumes selected by rational methods are frequently smaller than volumes selected by empirical methods. In these critical days when the conservation of raw materials is so vitally necessary, anything which contributes to a reduction in the size of equipment is of especial value. When the method of operation of an air conditioning system is changed, due to wartime conditions, best results are achieved if fundamentals are not disregarded. . . . The basic facts on the theory of air conditioning have been scattered through many different papers. In the article of which this is the third and concluding part, these facts have been gathered together and presented in a logical order which clearly shows the relationship between the various elements directly applicable to the design of air conditioning systems. No mathematical treatment is attempted. Instead, an attempt has been made to present in simple language a clear picture of the physical action taking place in the various component parts of air conditioning systems. . . . Mr. Goodman is consulting engineer, the Trane Co., and a member of HPAC's board of consulting & contributing editors

THE PSYCHROMETRIC chart is an invaluable aid in the design of air conditioning systems. More than this, it provides a simple and rapid means of understanding many otherwise complex phenomena in air conditioning. Many problems that are today simple and easy to visualize with the aid of the chart would require considerable work to visualize and solve without the aid of the chart.

Minimum Quantity of Heat for Reheating for Steep Percentage Lines

A discussion of the many methods available for reheating air is beyond the scope of this article. However, it is important to point out that the addition of sensible heat to the chilled air supply increases the refrigerating capacity required for the air conditioning system. The additional refrigerating capacity required is exactly equal to the amount of heat added during reheating. Consequently it is important to keep the quantity of heat that must be added for reheating to a minimum when such reheating is required because of a steep percentage line. [Percentage lines were explained in the December and January issues.]

In the simplified psychrometric chart of Fig. 10 are shown two reheating lines *6-7* and *4-5*. Although the length of line *6-7* is less than *4-5* (that is, the temperature change along *6-7* is smaller than along *4-5*), nevertheless the quantity of heat required for reheating along *6-7* will be greater than along *4-5*. Although the temperature rise along *4-5* is greater than along *6-7*, the quantity of air that must be reheated is less if it is supplied to the conditioned room in state *5* than if it is supplied in state *7*. It is because of this reduction in the air supply that the quantity of heat required for reheating is less along *4-5* than along *6-7*. In general, up to a certain point the lower the location of the reheating line on the psychrometric chart, the smaller will be the quantity of heat required for reheating.

However, if the air is cooled to low temperatures, the size of the compressor and its power requirements will increase. Whether or not the air should be cooled to a low temperature like point *4* of Fig. 10 or to some higher temperature like point *6* can be determined only for an individual case. Frequently the entire question may be decided on the advisability of avoiding difficulties with frost.

Reheating for Steep Percentage Lines by Mixing with Warmer Air Not Feasible

When reheating is necessitated by a steep percentage line, this reheating cannot usually be accomplished by mixing the chilled air supply with warm air. In an ordinary installation, warm air for reheating can be obtained only from the outdoors or from the conditioned room. In actual practice, however, reheating by mixing with outdoor air is not satisfactory, and reheating by mixing with warm return air will not produce the desired room condition in the case where the reheating is necessitated by a steep percentage line.

Frequently outdoor air may be

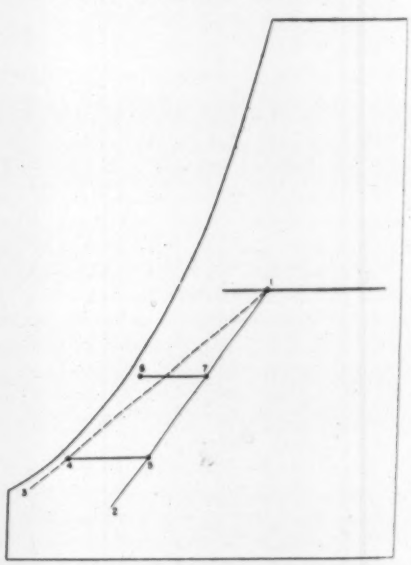


Fig. 10—Method of determining minimum quantity of heat required for reheating

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in such a condition that it is unsuitable for reheating purposes. Referring to Fig. 11, point *2* represents the condition to be maintained in a room for which the percentage line is *1-2*. In order to maintain the condition represented by point *2*, the air supply must be in a state that is represented by some point on the percentage line *1-2*. Assume that the outdoor air is represented by point *3* and the chilled air by point *4*. If the air supply consists

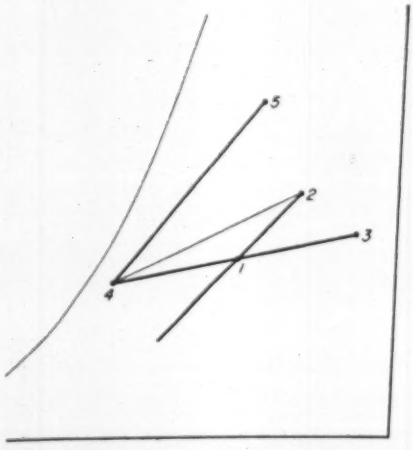


Fig. 11—Diagrammatic illustration of reheating with either outdoor air or return air

of a mixture of outdoor and chilled air, it is obvious that a mixture in state *1* on the percentage line *1-2* can easily be obtained. In this case the outdoor air can be used for reheating the chilled air because the line drawn from *3* to *4* intersects percentage line *1-2*.

However, outdoor air may not always be available in such a condition that the mixture line such as *3-4* will intersect the percentage line *1-2*. For example, if the state of the outdoor air were represented by a point such as *5*, the outdoor air would not be satisfactory for reheating because the line drawn from *4* to *5* does not intersect the percentage line *1-2*. Therefore, outdoor air in the condition represented by point *5* cannot be used for reheating purposes. Outdoor air is not ordinarily satisfactory for reheating because it is undependable—there is no assurance that when it is required for reheating it will be in a condition suitable for this purpose.

Return air cannot be used for reheating because the resulting condition of the mixture of return and chilled air will lie on line *2-4*. This line crosses the percentage line *1-2* at point *2* itself. Consequently, because the air supply must have a lower dry and wet bulb temperature than is being maintained in the conditioned room, it is evident that return air cannot be used for reheating when this reheating is necessitated by a steep percentage line.

Air Conditioning Cycle

At this point, sufficient elements have been presented to enable the complete air conditioning cycle to be traced on the psychrometric chart. Tracing a complete air conditioning cycle gives a very clear picture of the action that takes place during the conditioning of air. In Fig. 7 [on p. 28, January HPAC] point *1* represents the state of the air in the conditioned room and point *2* represents the condition of the outdoor air. Outdoor air and return air from the room are mixed ahead of the cooling coil. This mixing takes place along the line *1-2*. Air in state *3* is cooled and dehumidified by means of a cooling coil down to point *4*. Air in condition *4* is introduced into the conditioned room. This chilled air supply in the condition represented by point *4* is heated and humidified in the room until it leaves in the state represented by point *1*, which represents the state of the air to be maintained in the conditioned room.

If desired, in some systems return air from the room in the state represented by point *1* is mixed with the chilled air in the state represented by point *4*, giving an air supply in the state represented by point *5* on the same percentage line *1-4*. Air in condition *5* is introduced into the room and heats up along the percentage line until air is obtained in state *1* in the room.

Chemical Dehumidification—Another interesting cycle is obtained when chemical dehumidification is used, such as silica gel. With chemical dehumidification, a coil aftercooler is used. An elementary cycle of this type is illustrated in Fig. 12.

Assume again that the air in the conditioned room is to be maintained in the state represented by point *1*. Air in state *3* is obtained by mixing outdoor air in state *2* with the room air in state *1*. This mixture at point *3* enters the chemical dehumidifier and is heated along line *3-4*, which slopes downward along a line or curve slightly above the wet bulb line through point *3*. Theoretically, line *3-4* should coincide with the wet bulb line through point *4*. In any actual apparatus the two cannot coincide. Air leaving the dehumidifier in the state represented by point *4* enters the cooling coil and is cooled to point *5* on percentage line *1-5*. Air in state *5* then enters the room and heats up along the percentage line *1-5* to point *1* representing the room condition.

Dry Surface in Dehumidifying Coils

So far the discussion has been based on the assumption that the entire surface of the coil will be covered with a thin film of moisture condensed from the air. However, under some conditions, dehumidification of the air cannot begin until after the air has penetrated some distance through the coil.

Those who have had the opportunity of examining coils under various operating conditions have probably seen coils dry on their inlet face as far as the eye could penetrate into the maze of tubes and fins, and literally raining water from the fins on the outlet face where the cold air was leaving the coil. This was due to the fact that

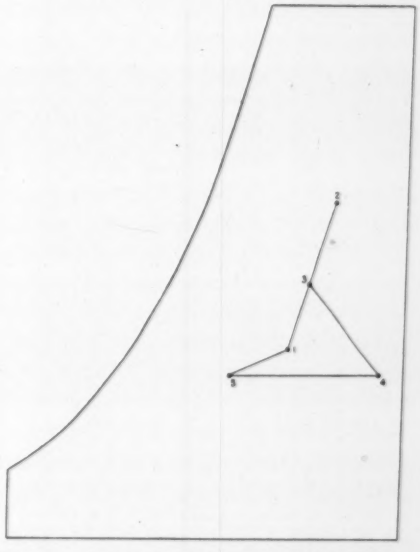


Fig. 12—Chemical dehumidification, followed by cooling with coil

no dehumidification of the air was taking place over an initial portion of the coil; dehumidification of the air did not begin until the air had penetrated some distance into the coil.

As has previously been stated, no condensation of moisture can take place until the temperature of the surface of the coil has been lowered to a temperature below the dew point temperature of the air passing through the coil. Moisture condenses on the cold surface of a glass pitcher of ice water only because the glass has been chilled to a temperature lower than the dew point temperature of the surrounding air. If the temperature of the metal forming the coil is higher than the dew point temperature of the air, obviously no condensation of moisture can take place—even though the dry bulb temperature of the air will be lowered by the cold metal.

As previously stated, in a wet coil the surface temperature of the metal is at some point between the *wet bulb* temperature of the air flowing over the coil and the temperature of the refrigerant. In a dry coil, on the other hand, the surface temperature of the metal is at some point between the *dry bulb* temperature of the air flowing over the coil and the temperature of the refrigerant. The dry bulb temperature of the air drops as it flows over a dry coil. Consequently, the surface temperature of the coil must also fall in the direction of the air flow through the coil. If the dry bulb temperature of the air is very high, the surface temperature will also be correspondingly high in a dry coil. As a result, the surface temperature of the metal may be higher than the initial dew point temperature of the air. This is true in spite of the fact that the refrigerant temperature may be considerably lower than the dew point temperature of the air. The air may be warm enough to prevent the refrigerant from cooling the metal surface to a temperature that is lower than the dew point temperature. Therefore, before dehumidification of the air can take place in the coil, the dry bulb temperature of the air must first be lowered to such a point that the surface temperature will fall to a temperature below the initial dew point temperature of the air.

All of the preceding discussion can be better understood by referring to the condition curve of Fig. 13. The initial condition of the air entering the coil is represented by point *A*. Because the surface temperature of the coil is higher than the initial dew point temperature of the air, no dehumidification of the air can take place. Consequently, the air cools from point *A* to point *B* without any dehumidification taking place —that is, the moisture content remains constant. When the dry bulb temperature of the air has fallen to point *B*, the refrigerant is able to cool the surface temperature of the coil to a temperature equal to the initial dew point temperature of the air. Consequently, after the air has been cooled to *B*, dehumidification of the air will begin because from point *B* onward the air is in contact with metal whose temperature is lower than the dew point temperature of the air flowing through the coil. The dry and wet bulb temperatures of the air at *B* are called the *boundary temperatures* because they represent the condition of the air as it flows over the imaginary line on the coil — the boundary — which separates the dry and wet portions of the coil.

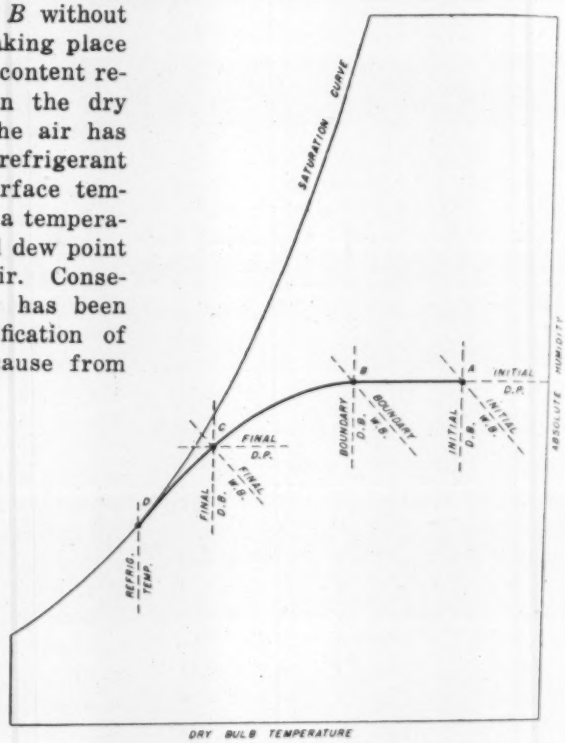


Fig. 13—Diagrammatic illustration of condition curve when an initial portion of the dehumidifying coil is dry. Note location of boundary at point *B* between the dry and wet portions of coil

There is no disadvantage to dry surface providing the coil has been so selected that the required dehumidification will take place. However, there is always the possibility that if dry surface occurs on the coil, the required dehumidification may not be obtained. Consequently, it is better to make certain that little or no dry surface will occur when the coil is in use.

With direct expansion coils operating at the suction temperature commonly used in air conditioning, there will usually not be much dry surface—if any. When using direct expansion coils, dry surface will usually be obtained only if the equipment is selected to operate at too high a suction temperature or if the initial dry bulb temperature of the air is abnormally high. When selecting the refrigerant temperature for which the equipment is to be designed, it is wise to check the characteristics of the coil to be sure that a low enough temperature has been chosen so that there will be little or no dry surface on the coil.

A Word of Warning When Using Water Coils

Because direct expansion coils are usually selected at a low suction temperature, there is little danger of an excessive amount of dry surface occurring on the coil in such systems. The chief danger of an excessive amount of dry surface occurs when using water. Chilled water is widely used with coils. Water is very often obtained from a well or sometimes purchased from a city. If the cost of the water or the cost of pumping it is rela-

tively high, there is always a strong temptation to use as little water as possible by allowing it to rise through a greater temperature range. If a certain amount of heat is to be absorbed from the air, the greater the temperature rise of the water, the less water will be needed to absorb the heat. However, the temperature rise of the water cannot be chosen at random. It is fixed by the limitations of the job.

The initial temperature of the water is beyond the control of the designing engineer. It is usually necessary to take water at the temperature at which it is available. However, the final temperature of the water depends upon the design of the coil. Theoretically, a coil can be designed to utilize a small quantity of water and heat it through a large temperature rise, or it can be designed to use a large quantity of water and heat it through a small rise. It is generally appreciated that the final temperature of the water can never rise above the initial dry bulb temperature of the air. However, it is not so generally appreciated that the final temperature of the water *should always be kept lower than the initial dew point temperature of the air.*

As previously stated, the temperature of the metal must be lower than the dew point temperature of the air if moisture is to condense on the surface of the coil. In order to keep the entire surface of the metal at a temperature lower than the dew point temperature, it is essential that the final temperature of the water should also be lower than the initial dew point temperature of the air. If the water temperature is allowed to rise to a temperature that is higher than the initial dew point temperature of the air, part of the coil surface will be dry—only a part of the coil will be cold enough to condense moisture from the air. While the coil will remove sensible heat from the air, there will be no dehumidification of the air as it flows over the dry part of the coil. Although a small amount of dry surface does little harm, there is always the possibility that so much of the coil may be dry that it will be difficult to maintain the desired relative humidities, even though it will be easy to hold the dry bulb temperature below the specified value. Consequently, it is good practice to use sufficient water to keep the final temperature of the water lower than the initial dew point temperature of the entering air. The only exception to this is the case in which the coil performance has been checked carefully to be sure that in spite of dry surface, the coil will always condense sufficient moisture to maintain the desired humidity in the conditioned spaces under all conditions.

ALTERNATE MATERIAL FOR DUCT CONSTRUCTION

THE EDITOR—

Our experience with asbestos cement ducts differs somewhat from that of Louis L. Narowetz, Jr., as described in his article in the January HPAC, and I would like to call attention to the differences.

Satisfactory asbestos cement sheets for both large and small ducts can be obtained that weigh less than 2 lb per sq ft instead of the 2½ lb noted by Mr. Narowetz. This item of weight is of some importance in the construction of ducts because it is obvious that lighter supporting members can be used for a light weight sheet.

Mr. Narowetz' experience on the cost of asbestos cement sheet ducts differs materially from the experience of several applicators that we have had occasion to work with. In the first place, a satisfactory 3/16 in. thick asbestos cement board can be obtained at a price slightly less than 24 ga galvanized iron. For ducts having small cross-sectional dimensions, a satisfactory ⅛ in. thick millboard type of asbestos cement material can be obtained materially below the cost of 24 ga galvanized iron. Therefore, the raw product cost of asbestos cement ducts is less than the raw product cost of metal ducts.

Contrary to Mr. Narowetz' experience, as far as the cost of labor to fabricate and assemble asbestos cement ducts is concerned, several applicators have actually developed methods and tools for handling a substitute material to a point where their overall labor cost for the ducts erected in place is less than with sheet metal ducts.

I feel that an asbestos cement type of duct has so many advantages over a sheet metal duct that in all probability this material will be used extensively for this purpose even when sheet metal is again easily available.—J. F. NICHOLAS, Keasbey & Mattison Co.

THE EDITOR—

In answer to Mr. Nicholas' point about the different weights encountered in the use of asbestos cement sheets, I agree with the variation and that there are several thicknesses to choose from, some of which are lighter than 2½ lb per sq ft. Since it has been my experience that the use of this material has strained the manufacturers' production capacity and obliged them to ship their product neglecting the complete curing of same and whereby the material arrives green, and is of consequence subject to more breakage than customary, for a large job it seemed advisable to select an average thickness, good for all duct sizes.

When considering cost we must include the size of sheets available and the breakage involved, and then the result will show a higher cost for the asbestos cement sheets. Asbestos cement sheets of ⅛ in. thickness were quoted in carload lots at a higher price than 3/16 in. thickness, this because the 3/16 in. is finished on only one side and the ⅛ in. is finished on both sides. In certain sizes, especially in increments of 12 in., when waste is kept down to a minimum and adaptable labor and material are available costs compare more favorably. But on a large project, subject to all kinds of help and green material, costs are higher, in my experience.

I expect there will be use or special need for asbestos cement sheets in air conditioning where insulation is of value, provided they are fabricated so as to meet fire underwriters' rules, but as to their entirely supplanting galvanized iron, I have no such expectancy.—LOUIS L. NAROWETZ, JR., Narowetz Heating & Ventilating Co.

Supplementary Plane PIPE BENDS

Samuel C. Zinman Presents Combined Graphical and Analytical Method for the Solution and the Transfer of Supplementary Plane Pipe Bends from the Drawing Board to the Shop for Fabrication

SUMMARY—A combined graphical and analytical method is presented for the solution and transfer of supplementary plane pipe bends, as encountered in ship construction, from the drawing board to the shop for fabrication. . . . In the general solution of bends involving more than one list angle, the author has eliminated the "breaking" of the middle lengths and the subsequent layout of the true lengths and angles as originally shown in Fig. 4 since they are calculated as part of the analytical solution. However, if the required accuracy of solution permits one which is entirely graphical, then the above convention may be used and the true lengths and angles scaled. . . . It is suggested that the draftsman have available a piece of lead about 20 in. long which can be bent easily and retain its shape. After the graphical study has been made, he can perform the bending and rotating procedure with this lead, approximating lengths and angles. Then, placing it in the position of the original plan and elevation he will obtain a rough check of his analysis. . . . The author has had considerable experience in marine and other piping design, and is now an assistant mechanical engineer with New York City's board of water supply

THIS ARTICLE is intended for piping engineers, draftsmen, and shop men who layout and design piping which does not show its true shape in the ordinary planes of projection. Piping of this nature is generally encountered in ship construction, boiler tubing, and sometimes land piping. The methods of solution of this problem are also adaptable to the layout of intersecting planes requiring the finding of the dihedral angle and other pertinent information that may occur in duct work or any similar three dimensional problem.

The methods of analysis outlined herein will consider the perfectly general case of piping that has angles of any magnitude between two intersecting pipe lengths and that lies in successive planes which are generally not at right angles to one another. This generalized piping which, when drawn in the ordinary planes of projection, does not show its true shape, will henceforth be known in this article as "supplementary plane piping" because the true shape of the piping lies in planes supplementary to the ordinary projection planes. Since piping under these conditions is best illustrated by piping bends, this medium will be used in the analysis.

Generalized Piping

A typical illustration of piping bends that have angles of any magnitude between two intersecting pipe lengths is shown in Fig. 1. Points *1*, *2*, *3*, *4*, and *5* comprise bends of this nature.

To introduce the notion of parts of the same piping lying in different planes generally not at right angles to one another, assume that the bolts in the flanges f_1 and f_2 of Fig. 1 are removed and the last bend f_2-*4*-*P* is rotated clockwise through some angle L using *4*-*3* as an axis (see section *E*-*E*). Hence P will move to P' and *3*-*4*-P' will lie in a plane different from the original plane (*3*-*4*-*5*) by the angle L.

From geometry we know that two straight lines determine a plane in space. It is therefore evident from Fig. 1 that *2*-*3*-*4* and *3*-*4*-P' each determine a plane, and since line *3*-*4* is common to both planes, it is their line of intersection. It also follows that the angle between these two planes is equal to the angle of rotation L, which is generally called the "list angle."

Notice that bolt hole H on f_2 has moved through angle L to position H'. For bends lying in the same plane (or in the usual plane of projection) it is standard practice to make bolt holes straddle the center lines lying in the plane of the bend (see Fig. 2). In this case, however, if the bolt holes of one of the bends straddles the center line lying in its plane, the bolt holes for the mating flange must be rotated from the plane of its bend through an angle equal to L and in the proper direction, depending upon whether the list angle is rotated clockwise or counterclockwise.

From the above discussion it is evident that, in the shop, generalized piping can be fabricated in much the same way as piping that is all in the same plane except that after the first bend is made, a rotation is necessary about the second tangent as an axis and then the second bend is made.

Fig. 3 illustrates this procedure. In position A, a length of pipe l is laid out on the bending table. With a length of tangent t_1 bend to right through angle $(\pi - a_1)$, using radius R (position B). With S as an axis lying in the bending plane, rotate t_1 counterclockwise through L_1 (position C). In position D, lay off t_2 and bend to left through $(\pi - a_2)$. Lay off t_3. Hence length l is now piping that is bent to any

Symbols and Definitions

Points in space indicated by numbers, *1*, *2*, *3*, *4*, etc., are the points of intersection of the true tangents to the bends.

$A_{1\text{-}2}$, $A_{2\text{-}3}$, $A_{3\text{-}4}$ are the true distances between the points of intersections in space in succession. Thus, the distances from *1* to *2*, *2* to *3*, etc., have distances $A_{1\text{-}2}$, $A_{2\text{-}3}$, etc.

$A_{1\text{-}3}$, $A_{2\text{-}4}$, $A_{3\text{-}5}$ are the true distances between alternate points of intersection in space. Thus, the distances from *1* to *3*, *2* to *4*, etc., have distances $A_{1\text{-}3}$, $A_{2\text{-}4}$, etc.

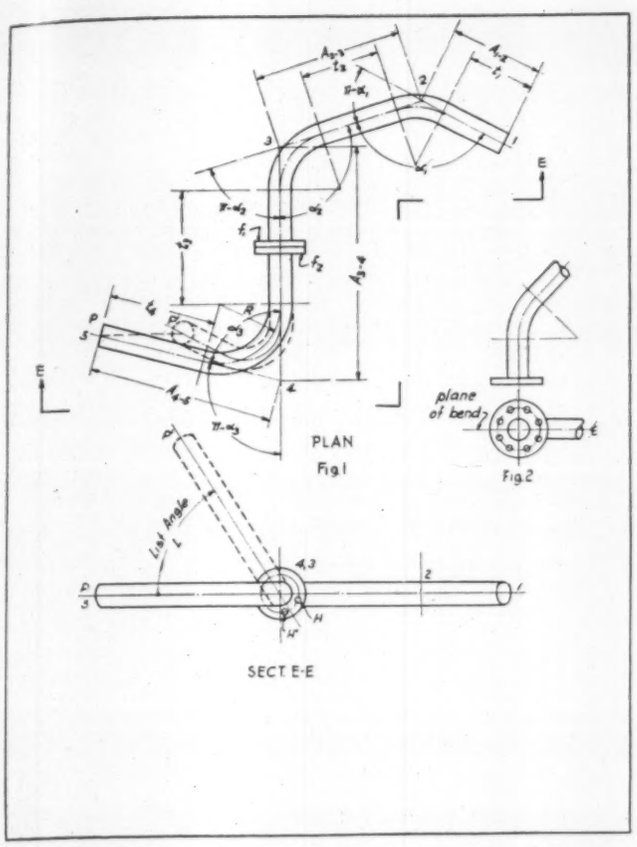
a_1, a_2, a_3, a_4 are the true angles between $A_{1\text{-}2}$ and $A_{2\text{-}3}$, $A_{3\text{-}4}$ and $A_{4\text{-}5}$, etc., and opposite $A_{1\text{-}3}$, $A_{2\text{-}4}$, $A_{3\text{-}5}$, etc.

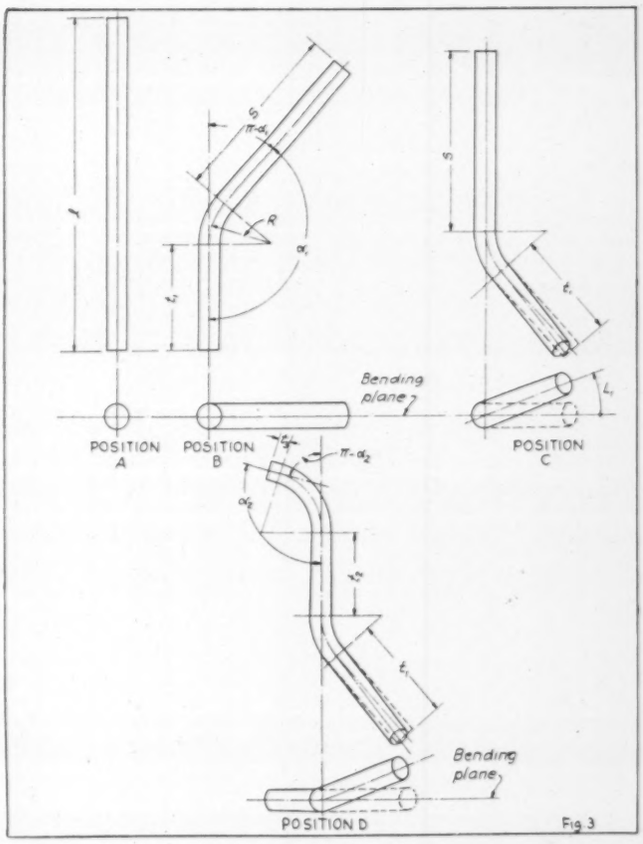
L_1, L_2, L_3, L_4 are list angles. Also dihedral angles. Angles between successive planes. Angles of rotation.

t_1, t_2, t_3 are tangent lengths between bends.

R is the radius of bend.

End View—Section showing three lines with middle line appearing as a point, which means a section showing intersection of two planes with the line of intersection appearing as a point.





angle and lying in different planes not necessarily at right angles to each other.

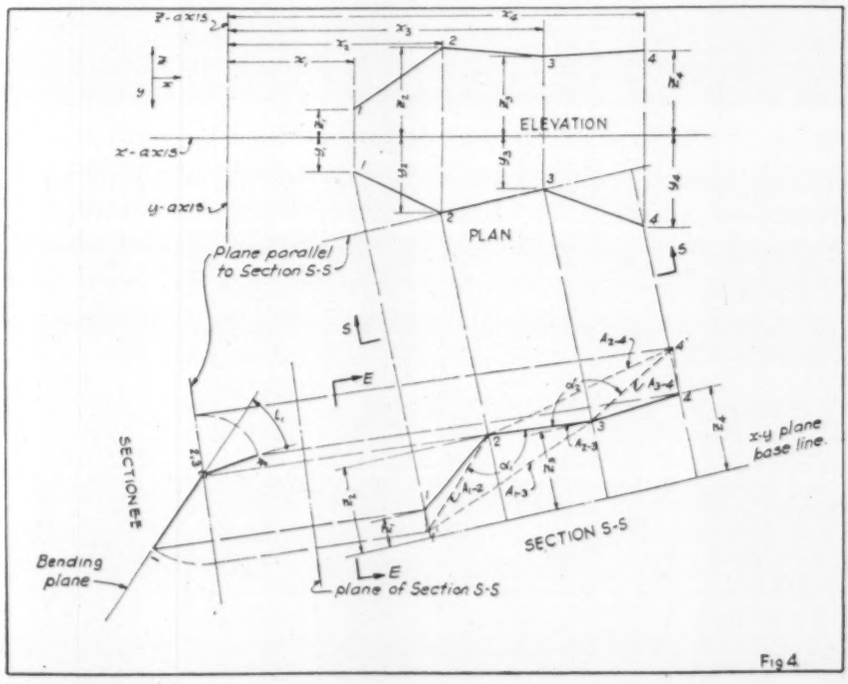
The information that the shop would then require for fabrication of these bends would be the tangent distances, true angles of bends and their direction (left or right), and the amount and direction of rotation (list angles). These data should be supplied in logical order, together with standard information such as pipe diameters, radius of bend, etc.

Supplementary Planes

The problem of layout and detailing of the piping as illustrated in Figs. 1 and 2 ordinarily would not be too difficult from the engineering and drafting standpoint. The computation or scaling of the true lengths and angles (A_{1-2}, A_{2-3}, etc.; a_1, a_2, a_3, etc.; and L) involve the use of trigonometric analysis or the advantageous selection of some section.

However, if these bends were placed in such a position that no true lengths or angles were apparent, the problem would then become more complex.

This piping (supplementary plane piping) is illustrated in Fig. 4 (plan and elevation) where, for simplification, the center lines



of the pipes are used instead of the pipes themselves.

In an actual problem the projections of the points of intersection of the true tangents (points *1*, *2*, *3*, and *4*) are determined by clearances from equipment and topography which are in the ordinary planes of projection. These points may then be coordinated from horizontal and vertical base lines which represent axes in space.

A graphical solution of this problem follows, and an analytical solution to it is given in Fig. 5.

Graphical Solution

Take a section *S-S* parallel to line *2-3* in the plan view of Fig. 4. The view shown in full results. It is evident that the *z* coordinate distances in this view are identical with those shown in the elevation view of Fig. 4.

Now rotate section *S-S* about its base line as an axis into the plane of the plan. Then take section *E-E*. This section shows an "end view" of the piping with the center length *2-3* appearing as a point. Comparing this to section *E-E* in Fig. 1 (after the pipe has been rotated), it will be seen that they are exactly alike. Hence L_1 is the list angle.

If we assume that *2-3* in section *E-E* (Fig. 4) is broken at some point along its length, we may rotate *1-2* and *3-4* about *2-3* as an axis into the plane parallel to section *S-S*. Since lines *1-2* and *3-4* generate cones in space, *1-1'* and *4-4'* in section *S-S* will both be perpendicular to line *2-3*. Hence we now have but one plane where the bends show true lengths and angles. The plane in which points *1*, *2*, and *3* all lie will be selected arbitrarily as the bending plane and list angle rotation will therefore be made into this plane.

[The second part of this article will cover multi-list angles and show the shop table.]

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FIG. 5

ANALYTICAL SOLUTION FOR PROBLEM SHOWN IN FIG. 4

True lengths of lines

$$A_{1\text{-}2}=\sqrt{(x_2-x_1)^2+(y_2-y_1)^2+(z_2-z_1)^2} \qquad A_{1\text{-}3}=\sqrt{(x_3-x_1)^2+(y_3-y_1)^2+(z_3-z_1)^2}$$

$$A_{2\text{-}3}=\sqrt{(x_3-x_2)^2+(y_3-y_2)^2+(z_3-z_2)^2} \qquad A_{2\text{-}4}=\sqrt{(x_4-x_2)^2+(y_4-y_2)^2+(z_4-z_2)^2}$$

$$A_{3\text{-}4}=\sqrt{(x_4-x_3)^2+(y_4-y_3)^2+(z_4-z_3)^2}$$

True angles

$$\cos\frac{\alpha_1}{2}=\sqrt{\frac{S_1(S_1-A_{1\text{-}3})}{A_{1\text{-}2}A_{2\text{-}3}}} \quad \text{where } S_1=\frac{A_{1\text{-}2}+A_{2\text{-}3}+A_{1\text{-}3}}{2}$$

$$\cos\frac{\alpha_2}{2}=\sqrt{\frac{S_2(S_2-A_{2\text{-}4})}{A_{2\text{-}3}A_{3\text{-}4}}} \quad \text{where } S_2=\frac{A_{2\text{-}3}+A_{3\text{-}4}+A_{2\text{-}4}}{2}$$

List Angle—(Angle between planes 1-2-3 and 2-3-4)

General equation of plane $ax+by+cz=d'$

For plane I (containing points 1,2,3)

$$ax_1+by_1+cz_1=d'$$
$$ax_2+by_2+cz_2=d'$$
$$ax_3+by_3+cz_3=d'$$

And using determinant notation

$$a=d'\frac{\begin{vmatrix}1 & y_1 & z_1\\ 1 & y_2 & z_2\\ 1 & y_3 & z_3\end{vmatrix}}{\begin{vmatrix}x_1 & y_1 & z_1\\ x_2 & y_2 & z_2\\ x_3 & y_3 & z_3\end{vmatrix}} \quad b=d'\frac{\begin{vmatrix}x_1 & 1 & z_1\\ x_2 & 1 & z_2\\ x_3 & 1 & z_3\end{vmatrix}}{\begin{vmatrix}x_1 & y_1 & z_1\\ x_2 & y_2 & z_2\\ x_3 & y_3 & z_3\end{vmatrix}} \quad c=d'\frac{\begin{vmatrix}x_1 & y_1 & 1\\ x_2 & y_2 & 1\\ x_3 & y_3 & 1\end{vmatrix}}{\begin{vmatrix}x_1 & y_1 & z_1\\ x_2 & y_2 & z_2\\ x_3 & y_3 & z_3\end{vmatrix}}$$

Hence equation for plane I is

$$\begin{vmatrix}1 & y_1 & z_1\\ 1 & y_2 & z_2\\ 1 & y_3 & z_3\end{vmatrix}x+\begin{vmatrix}x_1 & 1 & z_1\\ x_2 & 1 & z_2\\ x_3 & 1 & z_3\end{vmatrix}y+\begin{vmatrix}x_1 & y_1 & 1\\ x_2 & y_2 & 1\\ x_3 & y_3 & 1\end{vmatrix}z=\begin{vmatrix}x_1 & y_1 & z_1\\ x_2 & y_2 & z_2\\ x_3 & y_3 & z_3\end{vmatrix}$$

In the same manner the equation for plane II (containing points 2,3,4)

$$\begin{vmatrix}1 & y_2 & z_2\\ 1 & y_3 & z_3\\ 1 & y_4 & z_4\end{vmatrix}x+\begin{vmatrix}x_2 & 1 & z_2\\ x_3 & 1 & z_3\\ x_4 & 1 & z_4\end{vmatrix}y+\begin{vmatrix}x_2 & y_2 & 1\\ x_3 & y_3 & 1\\ x_4 & y_4 & 1\end{vmatrix}z=\begin{vmatrix}x_2 & y_2 & z_2\\ x_3 & y_3 & z_3\\ x_4 & y_4 & z_4\end{vmatrix}$$

Reducing determinants

Plane I

$$E_1=\begin{vmatrix}1 & y_1 & z_1\\ 1 & y_2 & z_2\\ 1 & y_3 & z_3\end{vmatrix}=\begin{vmatrix}1 & y_1 & z_1\\ 0 & y_2-y_1 & z_2-z_1\\ 0 & y_3-y_1 & z_3-z_1\end{vmatrix}=\begin{vmatrix}y_2-y_1 & z_2-z_1\\ y_3-y_1 & z_3-z_1\end{vmatrix}=(y_2-y_1)(z_3-z_1)-(y_3-y_1)(z_2-z_1)$$

$$F_1=\begin{vmatrix}x_1 & 1 & z_1\\ x_2 & 1 & z_2\\ x_3 & 1 & z_3\end{vmatrix}=\begin{vmatrix}x_1 & 1 & z_1\\ x_2-x_1 & 0 & z_2-z_1\\ x_3-x_1 & 0 & z_3-z_1\end{vmatrix}=\begin{vmatrix}x_2-x_1 & z_2-z_1\\ x_3-x_1 & z_3-z_1\end{vmatrix}=(x_2-x_1)(z_3-z_1)-(x_3-x_1)(z_2-z_1)$$

$$G_1=\begin{vmatrix}x_1 & y_1 & 1\\ x_2 & y_2 & 1\\ x_3 & y_3 & 1\end{vmatrix}=\begin{vmatrix}x_1 & y_1 & 1\\ x_2-x_1 & y_2-y_1 & 0\\ x_3-x_1 & y_3-y_1 & 0\end{vmatrix}=\begin{vmatrix}x_2-x_1 & y_2-y_1\\ x_3-x_1 & y_3-y_1\end{vmatrix}=(x_2-x_1)(y_3-y_1)-(x_3-x_1)(y_2-y_1)$$

And using the same method, for plane II

$$E_2=(y_3-y_2)(z_4-z_2)-(y_4-y_2)(z_3-z_2)$$
$$F_2=(x_3-x_2)(z_4-z_2)-(x_4-x_2)(z_3-z_2)$$
$$G_2=(x_3-x_2)(y_4-y_2)-(x_4-x_2)(y_3-y_2)$$

The angle between planes I and II is

$$\cos L_1=\frac{E_1E_2+F_1F_2+G_1G_2}{\sqrt{E_1^2+F_1^2+G_1^2}\times\sqrt{E_2^2+F_2^2+G_2^2}}$$

The study of the graphical solution will decide generally whether L_1 should be taken as acute or obtuse.

Tangent distances (see Fig. 1)

$$t_1=A_{1\text{-}2}-R\tan\left(\frac{\pi-\alpha_1}{2}\right)$$

$$t_2=A_{2\text{-}3}-R\left(\tan\frac{\pi-\alpha_1}{2}+\tan\frac{\pi-\alpha_2}{2}\right)$$

$$t_3=A_{3\text{-}4}-R\tan\left(\frac{\pi-\alpha_2}{2}\right)$$

INFORMATION AND FILTER CENTERS KEEP TAB ON ALL AIRCRAFT IN SKY

Samuel R. Lewis Tells of Heating, Ventilating, and Cooling Problems in the Aircraft Warning Service Operations Rooms Which Protect Us from Possible Enemy Air Attacks

SUMMARY—Information and filter centers, to which are reported all aircraft flying in a certain area, have been established in principal U. S. cities. Many of them are in leased spaces in intermediate stories of fireproof office buildings, old school buildings, etc. A number of heating, ventilating, and cooling problems required solution because of the heavy occupancy and lighting loads, necessity for blackout, etc. A typical installation involved a special steam riser from the building boiler room, new mains for steam or hot water heating, new electric cables from basement transformers, and new waste risers from toilets. . . . Mr. Lewis is a consulting mechanical engineer, and a member of HPAC's board of consulting & contributing editors

AIRCRAFT WARNING information and filter centers have been installed in many of our principal cities, covering a belt several hundred miles deep along our coasts. They were designed under the control of the Signal Corps and are operated by the Aircraft Warning Service. They were largely inspired by the experience in operating similar stations in England.

Most of them were completed prior to December, 1941. In many cases, the government leased spaces in intermediate stories in fireproof office buildings, rearranging the partitions to accommodate the specialized requirements. These requirements involve offices for the executives, a private telephone exchange, a canteen, rest rooms, lockers and toilets for men and women, and the operations room itself.

This room is always large enough to accommodate about 25 people seated around a great table shaped like the county or the several counties embraced in the particular zone. This table is painted with ruled lines which divide it into small rectangles. The lines in one direction might be given names, while those in the other direction are numbered, so that "Agnew 6," for example, can easily be spotted on the map table, with little danger of misunderstanding. Experience shows that "Emma 8" is more easily understood via telephone than "E8."

Along one side of the operations room is a balcony having its floor several feet above the floor on which the table rests, and having several glassed-in compartments within which the control officers may see all that goes on on the map table and still be able to telephone or telegraph without interference by noise in the room. There are always several small rooms adjacent to the operations room for use by commanding officers during an air raid and from which, if desired, they can more easily control the defending aircraft.

How Planes Are Reported

Around the map table there are always on duty the necessary number of operators, usually women, each with a telephone headset for receiving and a transmitter for acknowledging. Each operator is in touch with the watchers in her zone and if a plane goes up or is heard or seen, she receives a description of it, identification if possible, and is kept advised as to its direction.

The operator, for example, is told that a plane has been seen at "Agnew 4" and that it is a commercial, two engine plane headed east. Immediately she places a marker identifying such an aircraft on "Agnew 4" on the map. Very quickly a report reaches her neighbor operator that the plane has appeared at "Agnew 3" and the marker is moved to indicate this.

There may be many innocent planes in the zone, but all of them are identified and the progress of each across the zone is traced. The control officer can thus visualize all that is happening, airwise, in his sky. If enemy planes are heard or seen he knows about them, in many cases being forewarned of their approach long before they can be seen, due to improved sound reactors. He is able to communicate with the air fields which can send interceptor planes most effectively and rapidly, and from his high seat, via the map table and his staff

of operators, he can see what is happening with clarity and truth as no single man could see the situation were he alone even on a mountain top. Not only can the officer order up the interceptor aircraft, but he can control them via radio as the course of the battle renders new dispositions of the squadrons expedient.

Ventilation and Cooling Necessary

Even though the locations of the information centers are not particularly advertised, it is desirable that they be capable of being blacked out, which may mean closed windows, and mechanical ventilation is necessary. Since any interior room not much larger than a school classroom with perhaps 50 people in it, using brilliant illumination, will be a hot box in summer, provision for refrigerated air generally is made.

The existing ventilating and cooling—and even heating equipment—almost without exception was found inadequate, especially since an office building heating, ventilating, and cooling system rarely operates 24 hr per day, seven days per week, as information centers must operate. The more or less patriotic lessors to the government could hardly be expected to operate the heating or cooling system of a building 20 stories high merely to serve a part of the sixth story. Designers of mechanical equipment for buildings erected 10 years ago could not foresee any need for sixth story service independently of other stories. Rarely did we find adequate toilet arrangements for the 100 or more operators of an interceptor station, and in many cases the electric wiring was too light for the increased heavy wattage.

A typical installation involved a special steam supply riser from the boiler room, new mains for steam or hot water heating, new electric cables from basement transformers, and new waste risers from toilets. In many cases, rather than to disfigure the building with new mains and radiators, the existing radiators were removed and stored, and the heating and ventilating and cooling all were accomplished with ducts.

The installations which possibly were most successful involved outside air intakes, air filters, tempering convectors, a supply fan, and two superimposed convectors on the discharge side of the fan, serving two superimposed plenum chambers, the upper one with air temperature warmer the year around than that in the lower one. In winter the lower chamber is kept at around 65 F by control of the tempering heaters to windward of the fan and the upper chamber is at about 125 F due to steam in the upper convectors.

In summer the upper chamber air temperature is what the outside temperature allows, anywhere from 80 to 95 F, and the air temperature in the lower chamber is at about 60 F due to expansion of a refrigerant in the lower convectors. A separate air duct extends from both chambers to each room in the station, with a thermostatically controlled double blade mixing damper at the plenum chambers, capable of selecting enough air warmer or cooler than that in the respective room to maintain the desired condition therein. The refrigerating plant thus required for the average station is of some 50 tons capacity. In some cases evaporative condensers were employed, where city or well water is unduly warm or otherwise unacceptable, though due to the probable temporary lease the condenser water generally is wasted.

This scheme permits delivery into each room of the proper volume of air at the optimum temperature and desirable relative humidity, regardless of the temperature of the air being sent at the moment to any other rooms.

How Various Jobs Are Handled

This technique was not developed out of whole cloth in the first installation in a winter resort city, but the first one, due to inexperience by both the contracting officers and myself, was far from satisfactory, either in temperature or air distribution, and required some exceedingly interesting night and day observing and considerable correction. For example, side wall inlets in a large map table room resulted in objectionable drafts against some of the operators around the nearly circular table. The telephone room and private offices, sparsely occupied, were far too cold if the air supply, winter or summer, was cool enough to prevent overheating in the large crowded interceptor room.

No single temperature air delivery system could give satisfaction to so diversified an occupancy.

One of these stations was built into the auditorium of an old school building, which for a long time had been heated with natural gas unit heaters like stoves. We rejuvenated and remodeled the ancient bricked-in furnaces, installing supply fans and automatic temperature control in this case. Another station is in a completely air conditioned building, but the refrigerating plant is shut down every night and Sunday, and while the existing system was adapted for use during normal operating hours, an auxiliary supply and exhaust system was connected to four zones of the exceedingly complicated original duct arrangement, with two unit type 10 ton refrigerating plants serving the more critical rooms at off hours.

No two plants are alike. Each required a personal survey and night and day work of a considerable staff to develop the drawings, and complete them the "day before yesterday" or sooner.

Several of the interceptor stations are reinforced or backed up by more or less distant auxiliary duplicate stations, electrically connected, so that should one station be bombed or otherwise put out of service, the auxiliary station can take over quickly. All of them have gasoline or gas engine driven emergency electric lighting plants for automatic cutting in in case the public service electric energy should fail. Many have two independent sources of water supply.

They are all provided with exits and entrances independent from those used by the general public for the balance of each building. The selecting and leasing of adequate buildings, properly located, in the various cities was no small task, in which the Signal Corps and the architects participated, weighing carefully the multitudinous requirements as to location and structural condition.

Skidmore, Owings & Merrill, in association with Hugh Perrin and W. Earle Andrews, were the architects for all of the stations in which we designed the mechanical equipment.

Piping Connections for Cooling Stamping Blocks by Refrigeration

Unusual Process Use of Refrigeration Piping Is Described by F. F. Stevenson

SUMMARY—Mr. Stevenson, formerly with J. P. Baldwin Co. and now a supervising engineer in war work, describes the use of refrigeration for cooling the blocks on automatic stamping machines which handle a material which becomes sticky and difficult to process when heated. Channels were drilled in the blocks to form a U shaped passage. In one case, brine is piped to the blocks in order to cool them, and in another installation in the same plant, direct expansion refrigerant is employed

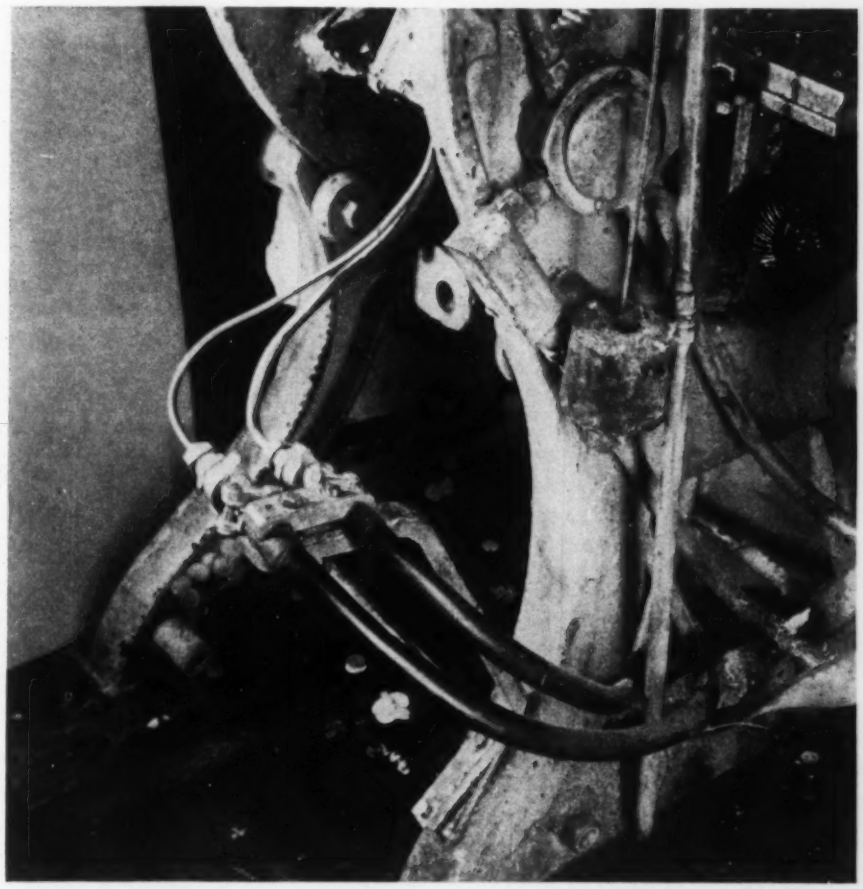
REFRIGERATION SERVES industry in many varied and useful ways, most of which are well known and understood. Occasionally, however, we see uses which are considerably off the beaten track, so to speak.

The installation described here is for cooling stamping blocks used on automatic stamping machines. These machines cut pieces of treated or coated cotton and cellulose material into various shapes and sizes. The operation is not high speed, about 40 to 60 strokes per minute, and the pieces are light and easily cut. Stationary steel blocks receive the impact of the stamper. With the machines in operation, these blocks naturally become warm; the impact of the stamper upon the block generates heat and the block absorbs some of it. When the block becomes heated, the materials in process are difficult to handle, as they tend to become sticky and production is slowed up, with spoilage of material.

The cooling of automatic stampers and blocks is not new, but most such applications are with materials in the rough, not affected by water or dampness. In this case, however, we were dealing with a finished product which is highly susceptible to moisture. However, it was decided to go ahead and see what could be done. Chilled brine was selected as the cooling medium, using a solution of water and calcium chloride.

The steel blocks are not large and vary in size with the pieces being cut. Some are about 12 in. long by 4 in. wide and 3 in. deep. Others are considerably smaller.

It was difficult, if not impossible, with the equipment at hand, to calculate the cooling load of each block exactly. However, some rough computations could be made. The specific heat of the steel is 0.12 Btu and the weights of the blocks vary from approximately 20 to 50 lb. If a block weighing 40 lb gained 50 F in temperature at the end of an hour's operation, then the heat absorbed by it would be 50x0.12x40 or 240 Btu. This does not represent the total heat generated by the stamping impact, because considerable heat is dissipated to the surrounding atmosphere, which is held at 70 F. With five or six machines in operation, the refrigeration load could be approximated at about 1/6 of a ton.



A U shaped passage was drilled in each stamping block, with two openings in the same end of the block. These openings form the inlet and outlet of the refrigeration system, affording two passes through the block. Here is some of the piping which conveys cooling effect to the block.

The first problem was how to make a cooler out of a stamping block. Channels 3/8 in. in diameter were drilled in the block along the two long sides. The channels were terminated about an inch or two from the opposite end. Then another channel was drilled along the short side, bisecting the two longer channels. The outer ends of the short channel were plugged up so that what finally resulted was a U shaped passage, with two openings in the same end of the block. These openings form the inlet and the outlet of the brine circulating system, affording two passes through the block.

Suitable fittings were provided and the block was hooked up to the brine lines. The brine is chilled in

a small vertical tank adjacent to the battery of stamping machines. A spiral coil, bare tube evaporator is used, with methyl chloride as the refrigerant, and a thermal expansion valve with the bulb clamped on the coil inside the tank. An immersion type thermostat, with its thermal element also inside the tank, starts and stops the condensing unit according to the brine temperature.

The cool brine is pumped from the chiller through insulated piping to a supply manifold near the machines and about 7 ft from the floor. Individual brine supply lines with hand valves lead from this manifold to each machine, the lines being kept overhead and then dropped down below the level of the stamping block and then up again. The reason for this is that it is not possible to insulate the line close to the machine and if it came in from above there would be objectionable dripping. The brine return lines are similarly manifolded. The condensing unit is powered by a ⅓ hp motor and develops about 0.20 tons of refrigeration at around 20 F suction temperature.

The temperature of the brine entering the blocks is about 35 F. The compressor is equipped with a high side cutout, with a low side pressure control, the latter being a protective device only, as the chiller thermostat starts and stops the compressor motor. At first, a single speed motor was used, but later a variable speed capacitor motor was installed, because there are many times when only a part of the total number of machines are in use, and the compressor, running at normal speed, had entirely too much capacity for the load. The speed controller is manually operated by the foreman in charge of the machines and after a little practice he is able to adjust the speed to reflect the load, enabling the compressor to operate on satisfactory on and off cycles.

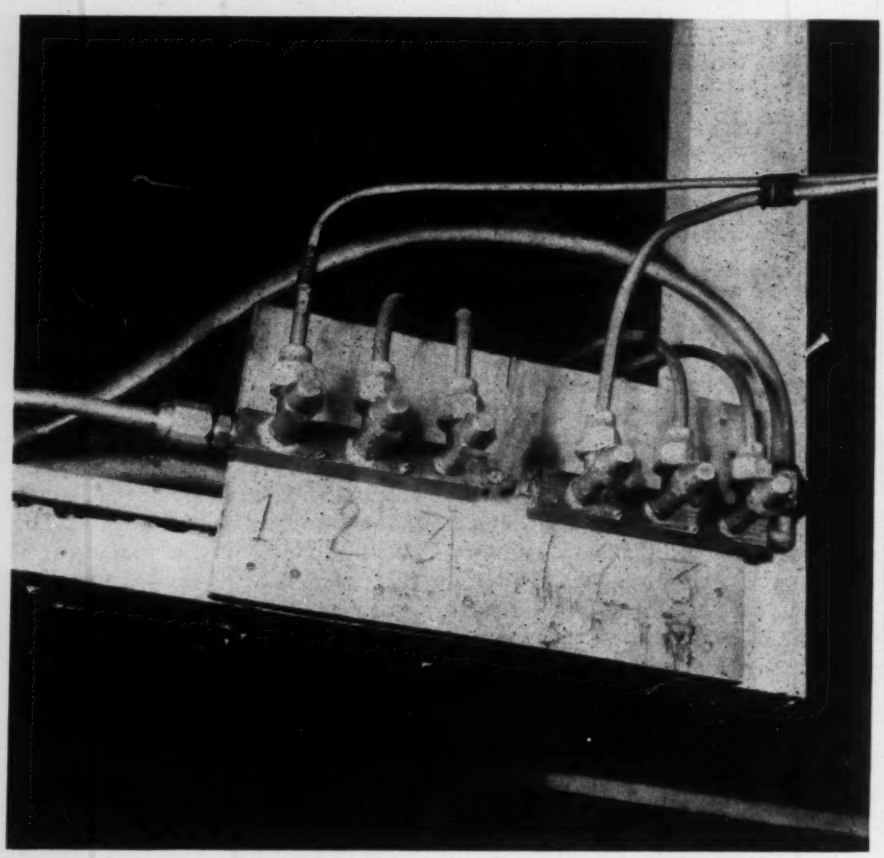
This little system has been running for some time, has been very satisfactory in its operation, and also has been instrumental in speeding up production and eliminating spoilage. Care must be taken not to permit the blocks to become too cold or else an objectionable sweating will result. The factory space is air conditioned and is held at about 70 F dry bulb and 40 per cent relative humidity. If the air dew point were much higher, the cooling of the blocks would not be practical, as it would be almost impossible to avoid excessive sweating. As the blocks are kept around 40 F, they absorb heat from the ambient air as well as heat from the stamping impact.

The job was complicated a bit at a later date by the introduction of two machines on which the blocks could not be kept in a fixed position. They move up and down in a vertical plane, the movement being 2 in. or less. To meet this situation flexible inlet and outlet lines were installed, each being semi-looped to allow for the continuous expansion and contraction of their lengths. Naturally, these connections must be made absolutely tight.

Sometime later a second battery of machines was installed and this time it was decided to try to cool the blocks by a direct expanding refrigerant. There was some objection to the use of brine around these machines and direct expansion would eliminate the brine chiller and pump.

A condensing unit of the same type and size as the one before described was selected, with methyl chloride as the refrigerant. Liquid and suction lines were run and manifolded and valved as previously described. The suction line was well insulated, where clear of the machines, to avoid sweating and dripping. A constant pressure expansion valve was placed in each branch liquid line, close to the refrigerated block. As these valves require regulation to provide occasional changes of evaporator pressure, they must be accessible. The same blocks were used as with the brine, but with different fittings. The refrigerant enters the block at one end, completes two passes, and emerges from the same end. The expansion valves were set to maintain a pressure corresponding to an evaporator temperature of about 35 F. The compressor has a high side cutout, and is started and stopped by hand. A single speed motor was used at first, but later it was discarded in favor of a variable speed motor. This installation has also operated successfully over a period of time.

The refrigeration piping is manifolded, with individual lines leading to each block.



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Journal Section

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49th Annual Meeting in Cincinnati

WITH A registration of 380, the Society held its second meeting during the war period, with a program that covered subjects of vital interest to engineers engaged in wartime activities.

This 49th Annual Meeting of the Society opened January 25 at the Hotel Gibson, Cincinnati, with First Vice-President M. F. Blankin presiding in the enforced absence of Prof. E. O. Eastwood, Seattle, Wash., President of the Society. In a brief speech Col. Charles Sherrill, City Manager of Cincinnati, welcomed the members to the city. A response was made by Mr. Blankin.

The reports of officers and committees were given and E. N. McDonnell, chairman of the Finance Committee, indicated that the financial condition of the Society was sound.

Lt.-Comdr. T. H. Urdahl presented his paper concerning warship ventilating, heating and air conditioning. W. B. Van Arsdel gave an interesting description of the engineering problems encountered in the new vegetable dehydration industry.

Immediately after the first session a Get-Together Luncheon was held in the ballroom of the Hotel Gibson, with the members of the Engineers' Club of Cincinnati. Fred F. McMinn, president of the Engineers Club, presided and Dr. B. M. Woods, member of the Council and professor of mechanical engineering, University of California, Berkeley, spoke on The Manpower Problem in Engineering to the 308 who attended.

The second session of the meeting was held on Monday afternoon, and Prof. D. W. Nelson, University of Wisconsin, co-author with G. E. Smedberg, presented the cooperative research paper on the performance of side outlets on horizontal ducts. R. E. Biller, Washington, D. C., gave a paper prepared by himself, Major L. C. McCabe and S. Konzo, on the Army fuel consumption studies for 1941-42. In an interesting presentation R. C. Cross, Chicago, described the performance characteristics of a coal-fired space heater, and explained some of the test results which had been obtained in the laboratory. W. S. Harris, who prepared a paper with Professors A. P. Kratz and M. K. Fahnestock, described the operation of the Research Home with reduced room temperatures at night.

Alfred J. Offner gave the report of the Guide Publication Committee, which showed a distribution of 10,300 copies of the 1942 edition, and reviewed the important changes that were made in the text of the 1943 edition to be issued in February.

The Tellers of Election reported the following results: *President*, M. F. Blankin, Philadelphia, Pa.; *First Vice-President*, S. H. Downs, Kalamazoo, Mich.; *Second Vice-President*, C.-E. A. Winslow, New Haven, Conn.; *Treasurer*, E. K. Campbell, Kansas City, Mo., and *Members of Council* elected for Three-Year Term as follows: J. F. Collins, Jr., James Holt, E. N. McDonnell and T. H. Urdahl. *Members of Committee on Research* for Three-Year Term are as follows: Dr. H. J. Rose, New York; L. P. Saunders, Lockport, N. Y.; Prof. L. E. Seeley, New Haven; Commander A. E. Stacey, Jr., New York; and C. Tasker, Toronto.

By action of the meeting the discussion of the amendments to the Constitution and By-Laws relating to the method of nominating officers was deferred until 9:00 a. m. on Tuesday morning.

The first item of business on the Tuesday morning program was the Report of Committee on Constitution and By-Laws which was given by Albert Buenger, chairman.

L. R. Vianey, Massachusetts Institute of Technonogy, and co-author with Prof. G. B. Wilkes, presented the paper on the effect of convection in ceiling insulation. Prof. C. O. Mackey, Cornell University, and co-author with L. T. Wright, Jr., gave the paper on summer comfort factors as influenced by the thermal properties of building materials. He was followed by Prof. F. E. Giesecke, Professor Emeritus at A. and M. College of Texas, who presented the results of his recent investigation on friction heads due to water flow in copper, brass and other smooth pipes. In the absence of the author, L. V. Teesdale, Madison, Wis., John James, Technical Secretary of the Society, presented the paper on the comparative resistance to vapor transmission of various building materials.

On Tuesday afternoon the Report of the Research Committee was given by F. C. McIntosh, chairman, and he summarized the reports of the 23 Technical Advisory Committees which had been serving during the year.

Lt.-Comdr. F. C. Houghten, U.S.N.R., presented the paper, which he prepared with Carl Gutberlet and Dr. M. B. Ferderber, on the physiological reactions applicable to workers in hot industries.

Vice-President Blankin then turned the meeting over to W. T. Jones, Boston, past president of the Society, who conducted the installation of officers with the assistance of Past Presidents Giesecke and Fleisher.

The concluding feature of the technical meeting was a Panel Discussion on the subject of how to keep fit in cold homes, which was conducted by C.-E. A. Winslow, the newly elected Second Vice-President of the Society, and the participants were: Dr. C. A. Mills, Cincinnati General Hospital, Cincinnati, Major W. J. McConnell, Chicago, Allen Johnson, Anthracite Industries Laboratories, Primos, Pa., R. A. Sherman, Battelle Memorial Institute, Columbus, Ohio, R. L. Davison, Director of Research, Pierce Foundation, New York, N. Y., Mrs. Ivah Deering, author and educator, Cincinnati, Edgar K. Ruth, housing manager, Cincinnati, and A. S. Bull, Insulation Board Institute, Minneapolis, Minn.

A number of Technical Committees held meetings on Sunday, January 24, as well as the Council of the Society and Chapter Delegates. An informal get-together was arranged for Sunday evening by the Cincinnati Chapter members and at 6:30 p. m. the Past Presidents held their annual dinner with the following present: W. H. Carrier and W. H. Driscoll, Syracuse, N. Y., W. L. Fleisher, New York, N. Y., F. E. Giesecke, Urbana, Ill., E. Holt Gurney, Toronto, W. T. Jones, Boston, Mass., and J. F. McIntire, Detroit.

The ladies were entertained on Monday at noon with a dessert bridge at the Hotel Gibson, and on Tuesday they enjoyed a luncheon and style show at one of the department stores.

On Monday evening a dinner and ice show were held at the Netherland Plaza and 324 members and guests attended.

The annual banquet was held in the roof garden at the Hotel Gibson on Tuesday evening with the Hon. Russell Wilson, former mayor of Cincinnati, as toastmaster. The speaker of the evening was Col. William N. Carey, Corps of Engineers and Chief Engineer for the Federal Works Agency, Washington, D. C. He briefly reviewed the achievements in the past year in creating a large fighting force and the more cheerful viewpoint than was apparent compared to a year ago. He concluded by saying that, if by planning a war over foreign tyrants can be won, it is also possible by planning to win the war against the tyrannies of depression, want and misery at home.

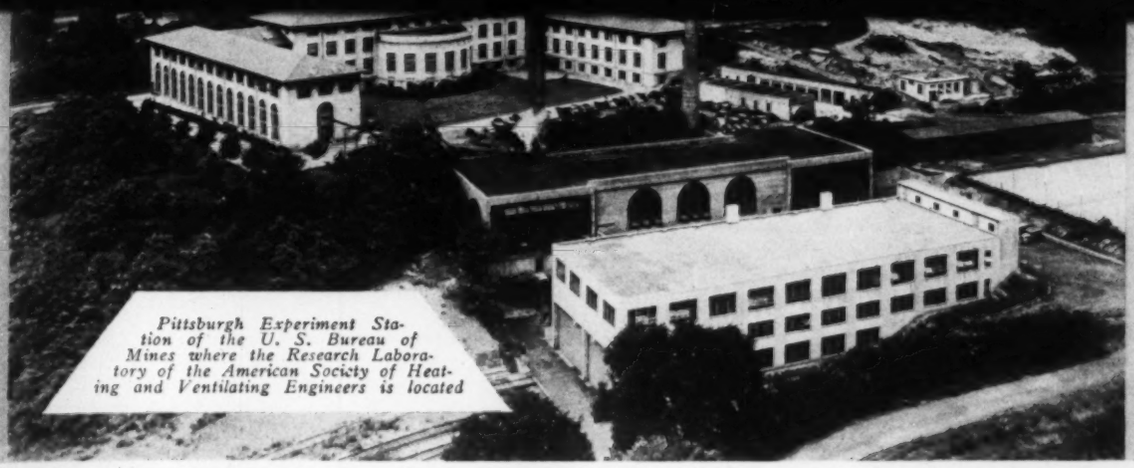
W. H. Driscoll, Past President of the Society, introduced President-elect M. F. Blankin, who presented the Life Membership Certificates to Dr. W. H. Carrier and Perry West.

F. C. McIntosh presented a plaque to J. H. Walker in appreciation of his services as technical advisor to the Committee on Research.

The banquet was followed by dancing to the music of Jimmy Wilber and his orchestra.

On Wednesday morning, January 27, the new Council held its organization meeting.

The proceedings of the 49th Annual Meeting are to be published in the March ASHVE Journal Section.



Pittsburgh Experiment Station of the U. S. Bureau of Mines where the Research Laboratory of the American Society of Heating and Ventilating Engineers is located

Committee on Research

Annual Report

1942

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J. H. Walker
Technical Adviser

C.-E. A. Winslow
Vice-Chairman

C. M. Ashley
Executive Committee

M. K. Fahnestock
Executive Committee

T. H. Urdahl
Executive Committee

F. C. Houghten
Director, First Quarter

C. M. Humphreys
Acting Director

THE WORK of the Committee on Research like most other enterprises, was affected by war conditions in 1942. Members of our Society were generally busier than usual, due to the national man-power shortage, and their lack of time for extraneous work was reflected in committee activities. To prevent an improper diversion of personal energy, no effort was made to conclude studies not related to the war economy.

At the Annual Meeting of the Society held in Philadelphia in January, the Council passed a resolution offering "without expense to the people of the United States through its Government, the full use of ASHVE Research facilities, including the specially trained personnel of its Laboratory." Subsequently this resolution was transmitted to a number of government agencies and several of them expressed interest.

The Committee on Research cooperated with the Society War Service Committee in meeting with such agencies to determine the character of research work that could best be undertaken. Several trips to Washington, D. C., were made in this connection.

On August 12, the United States Navy Department renewed a previous agreement with the Society to investigate several problems concerned with the basic design of heating, ventilating and air conditioning systems for naval vessels. In order to produce results at the earliest possible date, practically all other work at the Pittsburgh Laboratory was discontinued.

Although the number of contracts with Cooperating Institutions was the greatest in the history of the Society, no great progress was made, due to lack of man power and to a proper preference for other projects currently considered more important.

For the reasons given, reports of the 23 Research Technical Advisory Committees are generally more brief than heretofore.

COMMITTEE ON RESEARCH

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St. Louis, Mo.

A. E. Stacey, Jr.
Essex Falls, N. J.

F. C. McIntosh, *Chairman*
C.-E. A. Winslow, *Vice-Chairman*
J. H. Walker, *Technical Adviser*
C. M. Humphreys, *Acting Director*
A. C. Fieldner, *Ex-Officio Member*

Philip Drinker
Boston, Mass.

C. A. McKeeman
Cleveland, Ohio

ONE YEAR

Philip Drinker — A. E. Stacey, Jr. — J. H. Van Alsburg
Axel Marin — J. H. Walker

J. A. Goff
Philadelphia, Pa.

Axel Marin
Ann Arbor, Mich.

TWO YEARS

C. M. Ashley — H. King McCain — F. C. McIntosh
M. K. Fahnestock — T. H. Urdahl

THREE YEARS

C. F. Boester — W. E. Heibel — C. A. McKeeman
J. A. Goff — C.-E. A. Winslow

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Atlanta, Ga.

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Washington, D. C.

John James
Technical Secretary

Navy Comments of Results from Prior Agreements

In renewing its agreement the Navy Department stated, "the results of investigations carried on by your Society under previous contracts have provided sound data which have had a marked effect in maintaining the fighting qualities of the officers and crew of naval vessels through improved design of heating, ventilating and air conditioning systems for vessels currently in operation. It is hoped that the research work currently required will be carried out as expeditiously as is consistently possible in order that several answers required may likewise be reflected in design at the earliest possible moment."

Navy Agreement

Two phases of the Navy work have been in progress, one at the ASHVE Research Laboratory and the other at the Case School of Applied Science in Cleveland, under a cooperative agreement. As in the past, reports of these tests will not be available to the membership but will be submitted to the Navy in confidential form.

The current project at the Case School of Applied Science is being conducted by Prof. G. L. Tuve, and is scheduled to be completed about April 1. An extension of the scope and time is under discussion.

The Pittsburgh Laboratory program required considerable exploratory work to determine procedure, and this was established late in the year. The collection of official data, about half complete at the end of the year, is expected to be ready for report late in the summer. Former Director F. C. Houghten, a Lieutenant-Commander in the Naval Reserve, was called to active duty in April, and the Laboratory work was supervised, in the latter part of the year, by Prof. C. M. Humphreys of the Carnegie Institute of Technology, who was appointed Acting Director.

Technical Advisory Committees

Physiological Reactions

C.-E. A. Winslow*, *Chairman;* Dr. Thomas Bedford, Thomas Chester, Dr. E. F. DuBois, Dr. M. B. Ferderber, E. P. Heckel, John Howatt, Dr. R. W. Keeton, C. S. Leopold, André Missenard, Dr. R. R. Sayers, Charles Sheard, C. Tasker.

The committee is a continuing group having the responsibility of presenting at various intervals summaries of current physiological researches and their bearing on engineering practice. A comprehensive report on the physiological influence of atmospheric humidity was presented at the 1942 Annual Meeting, and it has been the feeling of this committee that new material bearing on this subject was insufficient to warrant a report this year.

Cooperative studies conducted under the auspices of this committee were continued during the early part of the year at the College of Medicine of the University of Illinois in Chicago to determine the physiological reactions of individuals entering a cooled space from a hot moist environment. In October the work at this institution was discontinued to allow more time to be spent on an important government research assignment.

Sensations of Comfort

Thomas Chester, *Chairman;* N. D. Adams, C. R. Bellamy, G. D. Fife, W. F. Friend, E. P. Heckel, Dr. W. J. McConnell, F. C. McIntosh*, A. B. Newton, B. F. Raber, C. Tasker.

At the request of the Guide Publication Committee, Chapter 2, Physiological Principles of the 1942 edition of The Guide was reviewed and recommendations for its improvement were submitted.

From well authenticated information it was found that with summer cooling and dehumidifying, relative humidities of as low as 17 per cent were not objectionable with dry-bulb temperatures around 80 F. Consequently, it was thought that the shaded area of the ASHVE Comfort Chart could be extended below its present lower limit at the 30 per cent relative humidity line to 20 per cent relative humidity.

However, it was decided to hold this in abeyance until such time that the Comfort Chart could be checked in other respects, with a view to the preparation of a completely amended form. This work and other recommendations for research submitted by this committee will necessarily have to wait until more important government assigned research has been completed.

A paper entitled, Comfort with Summer Air Conditioning contributed by this Committee was presented at the 1942 Annual Meeting.

Removal Atmospheric Impurities

Dr. Leonard Greenburg, *Chairman;* J. J. Burke, J. M. DallaValle, R. S. Dill, Theodore Hatch, L. R. Koller, C. A. McKeeman,* F. H. Munkelt, H. C. Murphy, G. W. Penney, Dr. E. B. Phelps, F. B. Rowley, W. O. Vedder, J. H. Waggoner, R. P. Warren, W. F. Wells.

Since the previous report, this committee has been gathering and summarizing additional data and information to complete the outline of work already done in the fields of mechanical, chemical and bactericidal purification. After the completion of this outline it will be possible to indicate the gaps of knowledge requiring subsequent research. One member of the committee contributed a major revision to the chapter on Industrial Exhaust Systems for the 1943 edition of The Guide.

Radiation and Comfort

J. C. Fitts, *Chairman;* A. H. Barker, L. M. K. Boelter, E. L. Broderick, R. E. Daly, J. B. Fullman, E. R. Gurney, L. N. Hunter, A. P. Kratz, C. S. Leopold, L. L. Munier, D. W. Nelson, W. J. Olvany, G. W. Penney, W. R. Rhoton, C. J. Stermer, C.-E. A. Winslow*.

At the Philadelphia January 27, 1942 meeting of this Committee, it was decided that a field project should be sponsored to determine the mean radiant and dry-bulb temperatures in actual rooms heated by convection, radiator, and panel systems. Subsequently, the ASHVE Research Laboratory developed a test procedure and technique for conducting this work and a number of observations were made. A preliminary report covering this program is now being reviewed by the Committee.

Certain minor revisions to the equipment in the radiant test rooms at the Pittsburgh Laboratory were made during the latter part of the year with the expectation that some exploratory tests can be made. It is intended that these tests will attempt to determine how low the air temperature in a room having a considerable amount of radiant heat can be dropped and still have a normally clothed subject feel comfortable.

Research Papers—1942

1. Measurement of the Physical Properties of the Thermal Environment, by D. W. Nelson, Chairman, Research Technical Advisory Committee on Instruments (June 1942, Journal).
2. Effect of Vanes in Reducing Pressure Loss in Elbows in 7-Inch Square Ventilating Duct, by M. C. Stuart, C. F. Warner and W. C. Roberts (Lehigh) (September 1942, Journal).
3. Overloading of Viscous Air Filters During Accelerated Tests, by Frank B. Rowley and Richard C. Jordan (Minnesota) (July 1942, Journal).
4. Performance of Side Outlets on Horizontal Ducts, by D. W. Nelson, and G. E. Smedberg (Wisconsin) (November 1942, Journal).
5. Physiological Reactions Applicable to Workers in Hot Industries, by F. C. Houghten, Carl Gutberlet and M. B. Ferderber (Research Laboratory) (Annual Meeting, January 1943).

*Member of Committee on Research.

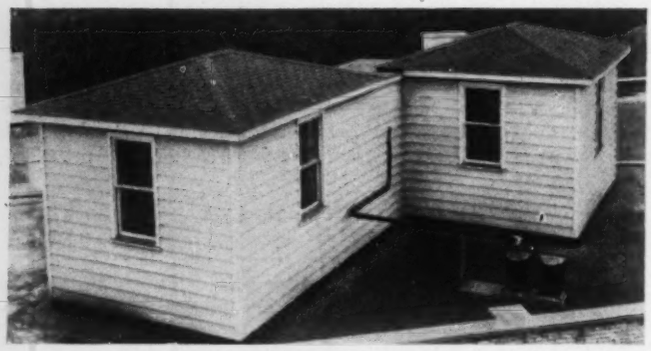

Fig. 1—View of radiation and comfort test building, ASHVE Research Laboratory

The cooperative work at the University of California coming under the supervision of this Committee has been continued with the view of developing experimental data which can be used to form the basis for more rationally designing a panel heating or cooling system.

Instruments

D. W. Nelson, *Chairman;* L. M. K. Boelter, R. S. Dill, A. P. Gagge, J. A. Goff*, A. E. Hershey, F. W. Reichelderfer, G. L. Tuve, C. P. Yaglou.

Recognizing the need for greater uniformity in reporting the measurement of the physical properties of a thermal environment, this Committee prepared a tentative outline of testing procedure, which was published in the form of a paper, entitled Measurement of the Physical Properties of the Thermal Environment (ASHVE Journal Section, Heating, Piping & Air Conditioning, June, 1942, p. 382). The four basic physical properties of the thermal environment as outlined in this report were listed as relative humidity, ambient air temperature, air movement, and mean radiant temperature. This outline is primarily intended for the guidance of research laboratory workers in this field of engineering and is not to be construed as a standard with which the industry is expected to comply.

Radiation with Gravity Air Circulation

M. K. Fahnestock*, *Chairman;* R. E. Daly, R. S. Dill, A. G. Dixon, H. F. Hutzel, J. P. Magos, J. W. McElgin, J. F. McIntire, T. A. Novotney, W. A. Rowe.

The progress of the work of this committee in the laboratories at the University of Illinois and in other cooperating laboratories has been severely curtailed on account of the war. Practically no progress has been made during the past year to complete the parts of the program mentioned under items Nos. 2 and 3 in the 1941 Annual Report. These items covered work to be done with radiators and convectors in several cooperating laboratories and in the cold room at the University of Illinois. All laboratories have been handicapped by a shortage of personnel which could be spared for this type of work.

A study of fluid pressure losses and heat transmission rates with water at various velocities and temperatures was actively pursued by the University of Illinois during the latter part of the year. A second warm wall test booth and auxiliary equipment providing facilities for studying the performance of radiators and convectors used with hot water has been built and placed in operation. Water velocities up to 15 inches per second with 1¼ in. connections, and water temperatures up to 240 F are available. Considerable progress has been made in calibrating the apparatus and in determining fluid pressure losses. The small tube cast-iron radiator, the copper convectors and the cast-iron convector to be used in the investigation have all been received and it is expected that good progress will be made in the future.

Weather Design Conditions

T. H. Urdahl*, *Chairman;* J. C. Albright, H. S. Birkett, P. D. Close, John Everetts, Jr., C. M. Humphreys, C. A. Kinzer, H. H. Koster, J. W. O'Neill, F. W. Reichelderfer.

The activities of the committee have been greatly restricted by the war which has handicapped more active participation on the part of the Chairman and several committee members. A full year of record data obtained at various selected locations in the city of Washington, D. C., is now available and it is hoped that an analysis of these data will be made early next year to show temperature variations which occur within a locality. It is felt that the information obtained may have an important bearing upon the present basis of fuel rationing which is predicated to a large extent for quantitative measure upon the degree-day which takes into consideration the temperature for a locality as a whole, though it is known that variations in the total will exist depending upon the location of the weather station upon whose readings the degree-day data will be based. The data developed under direction of this committee and the U. S. Weather Bureau indicating the severity of weather conditions through combination of low temperatures and high wind velocities should also afford some analysis serving a more useful purpose as fuel rationing criteria, especially for those vicinities where high prevailing winds will increase the heating requirement far beyond that indicated by the degree-day.

Heat Transfer of Finned Tubes with Forced Air Circulation

W. E. Heibel*, *Chairman;* C. M. Ashley*, William Goodman, H. F. Hutzel, Ferdinand Jehle, S. F. Nicoll, R. H. Norris, L. P. Saunders, R. J. Tenkonohy, G. L. Tuve, D. C. Wiley.

The major objective of this Committee has been to outline a research program for accurately determining coefficients for use in connection with the testing of finned tube heat transfer surface. Items which the Committee are interested in investigating include:

1. A study of the transfer of heat through water films existing on the external surface of finned tubes of various types.

2. Determination of film coefficients for refrigerants within the tubes: (a) with pure vaporizing refrigerants; (b) with refrigerant gas having various percentages of lubricant present; and (c) with liquid refrigerant both pure and combined with lubricants.

3. Determination of the air pressure drop through coils having wetted surfaces.

Cooling Load in Summer Air Conditioning

C. M. Ashley*, *Chairman;* J. H. Carter, John Everetts, Jr., F. C. Houghten, E. H. Hyde, C. S. Leopold, C. O. Mackey, R. M. Stikeleather, J. H. Walker*, W. E. Zieber.

A report giving the 24-hour heat gain rates for 11 walls and 18 roofs, having wide variation in resistance to heat flow and capacity, was presented at the 1942 Annual Meeting, as a contribution of this committee. The data presented in this paper are considered important as an initial contribution towards a more accurate method of determining the cooling load of a structure. Further study of the data is necessary to determine how the observed heat flows compare with the theory relating heat flow to the orientation, heat capacity, transmittance coefficient and absorptivity of solar radiation by the outside surface of the structure.

The committee was also responsible for supervising the cooperative investigation at Columbia University covering the periodic heat flow through walls having different heat capacities and thermal resistances. A preliminary report covering this project will be available for committee review at the time of the 1943 Annual Meeting.

Air Distribution and Air Friction

J. H. Van Alsburg*, *Chairman;* S. H. Downs, A. E. Hershey, W. W. Kennedy, A. P. Kratz, R. D. Madison, L. G. Miller, D. W. Nelson, C. H. Randolph, M. C. Stuart, Ernest Szekely, R. J. Tenkonohy, G. L. Tuve.

The activities of this Committee have been of necessity reduced, due to the shortage of adequate personnel and, therefore, the new work accomplished has not been of any great magnitude. Studies on the frictional resistance to the flow of air in round pipes at the ASHVE Research Laboratory have been temporarily discontinued. This also applies to additional projects coming under the supervision of this Committee, which were previously assigned to Lehigh University, Case School of Applied Science, Michigan State College, University of Wisconsin, and the University of Illinois.

As a result of work conducted during the early part of this year at Lehigh University, a paper, Effect of Vanes in Reducing Pressure Loss in Elbows in 7-Inch Square Ventilating Duct, was presented at the 1942 Summer Meeting. A paper, entitled The Performance of Side Outlets on Horizontal Ducts, will be given at the 1943 Annual Meeting, covering cooperative research conducted at the University of Wisconsin.

Sound Control

J. S. Parkinson, *Chairman;* C. M. Ashley*, W. W. Kennedy, A. L. Kimball, V. O. Knudsen, R. D. Madison, C. H. Randolph, A. E. Stacey, Jr.*, A. G. Sutcliffe, T. A. Walters, R. M. Watt, Jr.

The research program of this committee has been designed to procure fundamental data in order to establish background noise levels encountered in air conditioned spaces and to work out engineering procedures which would permit the prediction of such levels.

Cooperative work with Rensselaer Polytechnic Institute was continued this year in order to obtain additional information for predicting sound attenuation through a duct system. The paper reporting the attenuations measured in straight ducts was presented at the 1942 Annual Meeting.

Institutions Cooperating with the Committee on Research

Agricultural & Mechanical College of Texas
Frictional Flow of Water in Pipes and Elbows
Heating Requirements of Buildings

University of California
Performance of Cooling Towers
Radiant Heating and Cooling

Carnegie Institute of Technology
Corrosion in Steam Heating Systems

Case School of Applied Science
Air Distribution in Air Conditioned Spaces

Columbia University
Heat Flow Through Various Building Walls

Georgia School of Technology
Cooling of a Structure with Attic Fans

University of Illinois, Engineering
Radiator and Convector Studies
Residence Summer Air Conditioning
Air Distribution Outlets

University of Illinois, Medical School
Human Responses to Physiological Reactions

Lehigh University
Frictional Resistance to the Flow of Air Through Elbows

Michigan State College
Air Flow in Duct Transitions

Oregon State College
Heat Flow Through Wet Building Walls

University of Minnesota
Methods of Testing Air Cleaning Devices

University of Pennsylvania
Measuring Departures from Dalton's Law of Air-Water Vapor Mixtures

Rensselaer Polytechnic Institute
Sound Transmission in Ducts and Transitions

University of Wisconsin
Effect of Entering Air Temperature and Velocity on Distribution of Air in Enclosed Spaces

Fig. 2—Equipment for investigating performance of side outlets on ducts, University of Wisconsin

This paper also described test instruments and techniques for making noise measurements in duct systems. The research program at Rensselaer is being continued to investigate the attenuation in bends, elbows, splitters, etc.

A tentative testing procedure has been developed by the committee for measuring the amount of noise generated by air conditioning equipment. The committee is encouraging individual experimentation to check the principles outlined in this standard in order that necessary revisions to the procedure may be subsequently considered.

Air Conditioning Requirements of Glass

R. A. Miller, *Chairman;* C. M. Ashley*, L. T. Avery, F. L. Bishop, D. A. Bridges, W. A. Danielson, H. C. Dickinson, J. D. Edwards, J. E. Frazier, E. H. Hobbie, C. L. Kribs, Jr., Axel Marin*, F. W. Parkinson, W. C. Randall, L. T. Sherwood, J. T. Staples, G. B. Watkins, F. C. Weinert.

Early in the year the committee decided not to attempt any detailed research program, but to keep in touch with conditions as they arose, and if some worthwhile investigation developed, to study the possibilities of research along that line. Earmarked funds are available for additional research. After the death on July 13, 1942, of former chairman M. L. Carr, he was succeeded by R. A. Miller. The membership of the committee recorded its sentiment to the effect that its past achievements were largely due to the prominent influence and personal endeavor of Mr. Carr.

Psychrometry

J. A. Goff*, *Chairman;* F. R. Bichowsky, W. H. Carrier, H. C. Dickinson, R. S. Dill, A. W. Gauger, William Goodman, A. M. Greene, Jr., L. P. Harrison, F. G. Keyes, A. P. Kratz, D. M. Little, Axel Marin*, D. W. Nelson, W. M. Sawdon.

The second progress report sponsored by this committee was presented at the 1942 Annual Meeting in the form of a paper entitled Vapor-Pressure of Ice From 32 to -280 F. These calculated values of vapor-pressure will be incorporated in the final formulation of the thermodynamic properties of moist air which is one of the principal objectives of the committee. Experimental work on the measurement of the interaction constant for moist air has continued under the cooperative agreement with the Towne Scientific School, University of Pennsylvania. These measurements have been extended to cover the range 15 to 30 C. They indicate a downward revision of the tentative value 0.075 reported in the first progress report to something like 0.055 with a small negative temperature coefficient. New data will shortly be presented to the committee for criticism and evaluation with a view toward acceptance as best information available at present.

Cooling Towers, Evaporative Condensers and Spray Ponds

B. M. Woods, *Chairman;* C. F. Boester,* W. W. Cockins, S. C. Coey, E. H. Kendall, S. R. Lewis, H. B. Nottage, J. F. Park, E. T. Selig, Jr., E. W. Simons, E. H. Taze.

The work on cooling towers and spray ponds has progressed along the following course since the previous report.

1. Tests on a spray tower, with several different types of nozzles (3) were finished.

2. Further work is being done, especially with the purpose of evaluating nozzle performance.

3. Test results on two types of nozzles in a spray pond have been evaluated.

4. The performance of spray towers and ponds has been presented on a unit volume conductance basis.

5. A method of measuring unit mass conductances of single elements has been proposed in collaboration with others.

Flow of Fluids Through Pipes and Fittings

S. R. Lewis, *Chairman;* L. A. Cherry, G. C. Davis, T. M. Dugan, Earle W. Gray, R. T. Kern, H. A. Lockhart, Axel Marin,* R. F. Taylor, E. L. Weber.

The determination of proper allowances for resistances to flow of liquids of various kinds through pipes, valves, fittings, heat receivers and transmitters is the major objective of this committee. Some additional observations were contemplated at A. & M. College of Texas on the time incrustation effect of resistance to flow of water in pipes. However, there is some evidence to indicate that this incrustation is largely dependent on the kind of pipe, the quality of water, and on the number of times the system is drained.

Heat Requirements of Buildings

P. D. Close, *Chairman;* E. K. Campbell, J. F. Collins, Jr., E. F. Dawson, W. H. Driscoll, H. M. Hart, E. C. Lloyd, H. H. Mather, H. King McCain*, M. W. MacRae, C. H. Pesterfield, F. B. Rowley, R. K. Thulman.

Consideration was given to the continuation of the basement heat loss study, the initial results of which were reported in the paper Heat Loss Through Basement Walls and Floors, which was presented at the 1942 Annual Meeting. In the continuation of this study attention is being given to the effect of insulation in reducing condensation on basement walls in the summer, to the determination of ground temperatures below the basement floor and to check tests on basement floor losses in actual residences and in other locations.

Fig. 3—Apparatus for measuring temperatures and heat flow through basement walls and floors, ASHVE Research Laboratory

At a meeting of the committee in Philadelphia on January 27, 1942, it was decided to take steps to develop an ASHVE Short-Cut Method of Heat Loss Calculation which would be based on the current Guide procedure and which would supplement but not take the place of the more accurate Guide method. Such a chart, applicable to one, one and one-half and two story houses has been developed and appears to give results approximating those obtained by the Guide method. An average residence heat loss problem can be solved in a matter of minutes by means of this chart which is being considered by the committee.

A paper bearing on the activities of this committee entitled Attic Temperatures, Ventilation and Heat Losses appeared in the ASHVE Journal Section, Heating, Piping & Air Conditioning, November, 1942, p. 694.

Fuels

R. A. Sherman, *Chairman;* R. M. Conner, R. S. Dill, R. B. Engdahl, A. C. Fieldner, L. N. Hunter, S. Konzo, W. M. Myler, Jr., H. J. Rose, C. E. Shaffer, T. H. Smoot, R. K. Thulman, T. H. Urdahl*, E. C. Webb.

This committee held its organization meeting at the 1942 Annual Meeting. A full discussion of projects in the utilization of fuels in heating and ventilating was held, and a program of action on the subjects of pulsation in oil-burner flames, of correct methods for the measurement of flue-gas temperatures in heating equipment, and of the scaling of metals in heating equipment was outlined. Because of the pressure of other activities related to the war, little progress on any of these lines was made during the year.

To cooperate with S. Konzo and A. P. Kratz, who were consultants to Major L. C. McCabe of the U. S. Engineers, a subcommittee consisting of H. J. Rose, W. M. Myler, Jr., and R. S. Dill was appointed to assist, when called upon by Mr. Konzo, in outlining methods for estimation of fuel requirements for army camps.

The Subcommittee on Papers, headed by Mr. Konzo, reviewed and submitted to the Society two papers on fuels for the 1943 Annual Meeting.

Summer Air Conditioning for Residences

M. K. Fahnestock,* *Chairman;* Emerson Brandt, E. D. Milener, F. G. Sedgwick.

No active research has been conducted under the auspices of this committee during the current year, and none has been suggested for the immediate future. However, a comprehensive outline of work to be done at some future date, previously prepared, may be referred to in the 1941 booklet Programs of the Research Technical Advisory Committees.

Sorbents

F. R. Bichowsky, *Chairman;* John Everetts, Jr., Ralph Fehr, John A. Goff,* W. R. Hainsworth, C. H. B. Hotchkiss, J. C. Patterson, G. L. Simpson.

This is a new committee appointed in 1942 to survey the field of air drying agents and to act as a central group for the clearing of technical information concerning adsorbent and absorbent techniques. It will be the function of this committee to gather and recommend for publication,

data on the properties of various drying agents. Fairly complete thermodynamic data on the properties of lithium chloride and lithium bromide solutions are available, but similar information regarding calcium chloride, calcium bromide and other sorbents seems to be lacking. This committee is planning to meet at the time of the 1943 Annual Meeting, where it is expected that definite plans will be outlined for future activity and progress.

Corrosion

L. F. Collins, *Chairman;* H. E. Adams, N. D. Adams, J. F. Barkley, W. H. Driscoll, T. J. Finnegan, W. Z. Friend, E. W. Guernsey, W. E. Heibel,* A. R. Mumford, R. R. Seeber, E. T. Selig, Jr., F. N. Speller, C. M. Sterne.

During the summer a cooperative agreement was concluded between the Society and Carnegie Institute of Technology to study the mechanism by which carbon dioxide entrained with steam becomes dissolved in the condensate formed in operating steam heating equipment. The actual work on this project started in September. Complementary studies along the same line are being conducted by The Detroit Edison Co. The latter are not yet complete. Even so, the results obtained appear to indicate two important points:

1. That in operating equipment, where the vapor space is not vented, steam and carbon dioxide do not always form a homogeneous mixture.

2. The heterogeneity of the gas mixture is conditioned by the velocity of flow of steam through the unit.

It is believed that both of these studies will, within the next year, clear up much of the confusion presently identified with the subject.

It was anticipated that during the year the committee would assemble considerable data on corrosion protection provided by suitable paints. Due to the pressure of war work on those committee members assigned to the problem, practically nothing was done. It is planned to carry this problem for another year.

Air Conditioning in Industry

W. L. Fleisher, *Chairman;* L. T. Avery, Dr. A. R. Behnke, Dr. Leonard Greenburg, W. E. Heibel,* L. L. Lewis, Dr. W. J. McConnell, Dr. C. P. McCord, P. A. McKittrick, Dr. R. R. Sayers, C. Tasker, R. M. Watt, Jr., H. E. Ziel.

Work was conducted at the ASHVE Research Laboratory early this year on the physiological reactions of persons to high temperature conditions. This work was partially planned to conform to the interest of the U. S. Navy and later continued in the extension of the Navy agreement.

A paper approved by this committee covering the Physiological Reactions Applicable to Workers in Hot Industries will be presented at the 1943 Annual Meeting.

Insulation

E. C. Lloyd, *Chairman;* H. King McCain*, J. D. Edwards, Paul McDermott, W. T. Miller, E. R. Queer, F. B. Rowley, G. L. Tuve, J. H. Waggoner.

This committee has not met during the year 1942. However, the members individually have given a great deal of thought to the problem of utilizing the new test code covering the guarded hot plate for developing better conductivity values for use of the Society.

It is true that the events of the year have to some degree made necessary a curtailment of committee activities, but it is certain that much is to be done and the committee hopes during 1943 to:

1. Study the need for research in the insulation field.

2. The newly adopted joint committee test code covers testing of insulating materials only by means of the guarded hot plate. In order to make possible the testing of all materials used as insulation and in building construction, it will be necessary to enlarge the scope of the code so as to properly test all types of products. Therefore the committee will study the need for enlargement of the scope of the joint committee test code so that it may embrace the testing of all available thermal insulating materials.

3. Establish a recommended procedure by which qualified laboratories may conduct the testing of all available thermal insulating materials under the proposed enlarged joint committee test code.

4. Consider the need for completely replacing the present Guide conductivity values with new values based on the proposed enlarged joint committee test code and on commercial materials currently available.

Heavy Duty Air Heating Furnaces

E. K. Campbell, *Chairman;* A. P. Kratz, W. J. MaGirl, B. B. Reilly.

Late in November this committee was appointed to analyze information on heavy duty furnaces with a view to determine whether sufficient data are available and whether there is a need for the Council to appoint a code committee. It is expected that this committee will have a report to submit at the time of the 1943 Annual Meeting.

Contributors to Research

Contributions in support of the research work of the Committee on Research are hereby acknowledged:

Financial Contributions

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The Effect of Convection in Ceiling Insulation

By G. B. Wilkes* and L. R. Vianey**, Cambridge, Mass.

SUMMARY—Tests have been made in a guarded box apparatus, placed in a horizontal position, in order to determine the rate of heat flow, upwards, through a typical frame ceiling insulated with various kinds of loose fill, bat and blanket insulation. The heat transmittance test values for the loose fill insulators are from 54 to 107 per cent higher than the present accepted values. The bat type insulators gave test values from 7 to 61 per cent higher than calculated values, while the tests on blanket insulation checked with the accepted calculated values exceptionally well considering the nature of the materials. This increase in the coefficients for loose fill insulation is shown to be largely due to heat transfer by convection from within the insulation to the air above. This effect is much less in the case of bat insulation and is apparently negligible in the case of blanket insulation

Effect of Convection in Ceiling Insulation

IT HAS been well established by many investigators that orientation of air spaces has a marked influence on the rate of heat transfer by convection. It is only natural that one would suspect a similar but lesser effect with loose and light weight insulators where there would be opportunity for free convection. To determine the amount of this effect, if any, a typical guarded box testing equipment was turned to a horizontal position with a test panel on the upper side which would represent a condition for maximum convection.

Test Method

The test panel consisted of a typical frame ceiling of 2 in. x 6 in. joists on 16 in. centers with ⅜ in. plasterboard on the bottom, as shown in Fig. 1. The test area, 32 in. x 32 in., was separated from the guard area by the joists on two sides and by 1 in. x 6 in. boards on the other two sides as diagrammed in Fig. 2, in order to avoid any possibility of convection transfer of heat between the test and guard areas of the panel. Any type of loose fill, bat or blanket insulation could be installed readily in this panel and the coefficient of heat transmittance determined. Shielded thermocouples were used to measure the air temperature on each side of the test panel and surface couples were attached to the lower side of the plasterboard. Fan circulation was maintained in both the guard and test boxes and photoelectric control was used to maintain the temperature of the guard box within a small fraction of a degree of the temperature in the test box.

Thermal equilibrium was established before any test observations were made and the time to complete a test was usually from three to four days. In general the average temperature of the air outside of the panel was about 75 F while the air inside was roughly 120 F, corresponding to a temperature difference of 45 F, which is a normal amount for New England.

The equipment, being new, was checked first with a 3 in. cork slab and the results of this test indicated that suitable results could be expected. The transmittance of the uninsulated ceiling was also determined at this time.

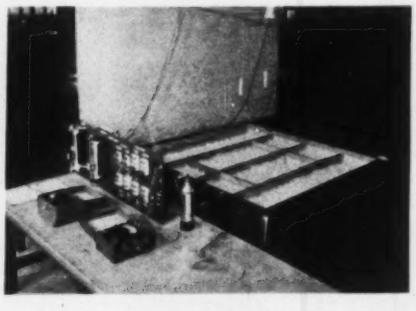

Fig. 1—Ceiling test apparatus

Insulating Materials

Loose Fill Insulation: Rock wool of the *blowing* type from two manufacturers was placed as evenly as possible between the joists on the plasterboard in thicknesses varying from 1 in. to 5½ in. A gage board was used to insure uniform distribution and accurate measurement of thickness. The bulk density of the rock wool was kept as low as possible and all samples tested had a bulk density between 5.0 and 6.2 lb per cubic foot.

One test was made with a 2 in. thickness of expanded mica with a bulk density of 7.2 lb per cubic foot.

Bats: Commercial bats from three different manufacturers and of two different thicknesses were tested in the same way. The density of these varied between 2.1 and 3.6 lb per cubic foot.

Blanket Insulation: Insulating blankets from two manufacturers with the thickness varying from 0.5 in. to 2.0 in. were attached to the upper side of the joists, thus making an additional enclosed air space between the blanket and the plasterboard. The blankets were attached to the joists with staples approximately 6 in. apart.

Results

The results are of real importance to the insulation of buildings because in the case of some types of insulation the test values are very much higher than the generally accepted figures used by our engineers and architects.

All values for the coefficients of heat transmission through ceilings in the ASHVE Guide, 1942, are calculated with no account taken of whether the heat flow is upward or downward across air spaces, from surfaces to air, or through the insulation. Technical Circular No. 7, Federal Housing Administration, 1940, gives calculated coefficients, for ceilings, in which the direction of heat flow is taken into account for air spaces and surface coeffi-

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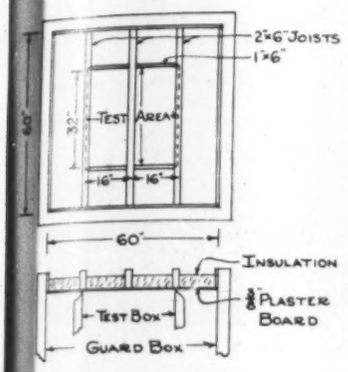

Fig. 2—Diagram of ceiling test panel

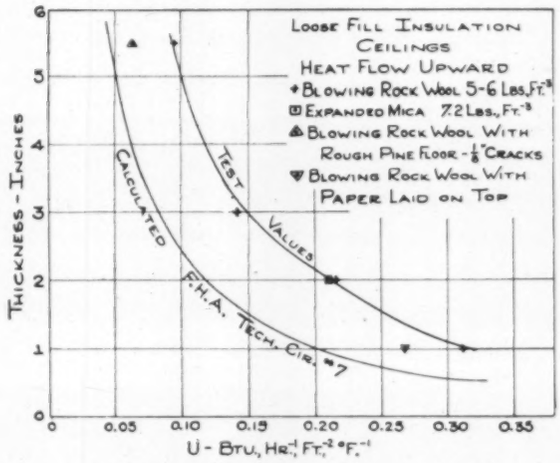
Loose Fill Insulation Ceilings
Heat Flow Upward
+ Blowing Rock Wool 5-6 Lbs./Ft.³
⊡ Expanded Mica 7.2 Lbs./Ft.³
▲ Blowing Rock Wool With Rough Pine Floor - 1/8" Cracks
▼ Blowing Rock Wool With Paper Laid on Top
Test Values
Calculated - F.H.A. Tech. Cir. #7
Thickness - Inches
U - Btu, Hr.⁻¹, Ft.⁻², °F.⁻¹

Fig. 3—Coefficients of heat transmission for various thicknesses of loose fill insulation

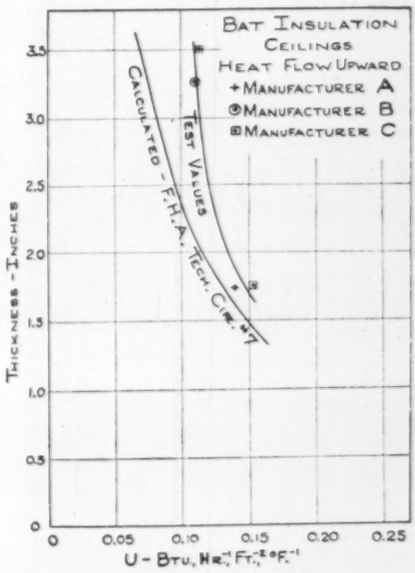

Fig. 4—Coefficients of heat transmission for various thicknesses of bat insulation

cients. No data were available to indicate the change in the coefficient of the insulating material with the direction of heat flow.

The results of these tests are shown in Table 1, and the accompanying charts show these test values graphically compared with the calculated values based on data in Technical Circular No. 7, Federal Housing Administration.

The test values for loose fill insulation as shown in Fig. 3 average 81 per cent higher than the accepted values today. If the test values for 1 in. and 5½ in. rock wool are omitted because they do not represent common practice, the remaining tests have coefficients that vary from 75 to 86 per cent greater than calculated values.

The bat type of insulation also gives larger heat transmittance test values than are used in common practice, averaging 34 per cent higher, and individual tests vary from 7 to 61 per cent higher, as illustrated in Fig. 4.

In the case of blanket insulation, one would expect considerable variation due to the nature of the materials and method of installation, since the thickness is uncertain and cannot be duplicated in many cases. From Fig. 5 it is evident that the U values for individual tests may vary somewhat, but it is also clear that the average test value for blanket insulation is very close to accepted practice, the difference for the average of these tests being only 2 per cent lower, which is negligible for work of this nature.

Discussion

The 18 tests on ceiling insulation with heat flow upward, covered by this paper, indicate rather conclusively that the present coefficients, used in calculating the rate of heat transfer through ceilings, are subject to very serious error in the case of loose fill insulation, some error for bat type insulation, but otherwise are essentially correct for blanket insulation and uninsulated ceilings.

It is rather obvious that the discrepancy between these tests and calculated values is primarily due to convection. With loose fill insulation, heat flow upward, the air in contact with the plasterboard becomes warmed and then tends to rise vertically because its density is less than the colder air above the insulation. The loose insulation offers little resistance to the passage of this air and consequently heat is transferred by convection from the plasterboard to the upper air. This convection heat transfer is sufficient to nearly double the calculated value of the ceiling coefficient in some cases.

In Table 1, a test is shown with 5.5 in. of blowing rock wool open on top; this test was repeated with the same thickness of insulation and the addition of a rough pine floor with ⅛ in. cracks laid across the top of the joists. The U value was lowered from 0.095 to 0.063 (34 per cent) by this floor. This reduction in U value is far greater than can be accounted for by the insulating effect of the floor alone. It seems only reasonable to conclude that most of this reduction in value is due to the smaller amount of heat transfer by convection.

An additional check on this effect is shown in Table 1 by comparing the reduction of the U value by laying a single sheet of paper over 1 in. loose rock wool. In this case the U value was reduced from 0.312 to 0.268 (14 per cent) by the addition of one layer of paper. This obviously cannot be caused by the insulating effect of the paper but is undoubtedly due primarily to the reduced convection.

If one uses the U values as determined by test for the uninsulated and insulated ceilings, the *apparent* coefficient of thermal conductivity, K', of the insulation may be calculated.

Given $U = 0.77$ for the uninsulated ceiling
$U = 0.216$ for the ceiling insulated with 2-in. rock wool

Then $$\frac{1}{0.216} = \frac{1}{0.77} + \frac{2}{K'}$$

And $K' = 0.56$ Btu, hr^{-1}, ft^{-2}, F^{-1} in.

It has been well established by many observers that the K value for rock wool as determined in the guarded plate apparatus is approximately one-half of the value indicated, K'.

Similar calculations were made for the apparent coefficient, K', for other thicknesses of rock wool with the results as shown in Table 2.

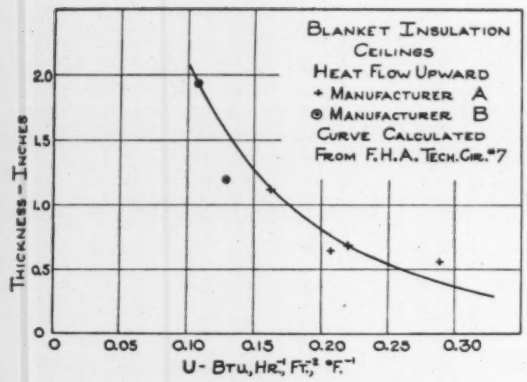

Fig. 5—Coefficients of heat transmission for various thicknesses of blanket insulation

The apparent coefficient, K', for blowing rock wool used under the above specified conditions is approximately double the plate test value.

With bat type insulation, the arrangement of the fibers is evidently such that convection is more effectively retarded than with loose fill materials, but there is sufficient convection in some bats to cause considerable error if the usual K value is used for calculations.

The apparent coefficient, K', calculated on the same basis as the loose rock wool above, varies considerably for some manufacturers as shown in Table 3.

The apparent coefficient, K', indicates values from 11 per cent to 70 per cent greater than the generally accepted coefficient, K, for materials of this nature.

The transfer of heat by convection through the insulating medium is effectively stopped by blanket insulation and the test values agree fairly well with the calculated values. These tests give additional confirmation that convection is responsible for the high values in the case of loose fill insulation.

Conclusions

With heat flow upward through ceiling insulation, the accepted calculated values for U are much too low for loose fill insulation and somewhat low for bat insulation. Transfer of heat by convection in the insulation is responsible for this error. The test values of U for ceilings insulated with blanket insulation appear to check fairly well with present calculations.

For the calculation of heat loss through ceilings, with no flooring and heat flowing upward, the K value for *blowing* type rock wool and expanded mica used as loose fill insulation should be increased about 80 per cent to give results that agree with test values. Other loose fill insulations should also have their K value increased proportionally until further data become available.

In calculating the rate of heat loss for bat insulation under similar conditions, the K value should be increased. The actual amount of this increase varies between 7 per cent and 61 per cent for the three types of bats used in these tests.

Table 1—Ceiling tests—heat flow upward

	Insulation	Thickness (inches)	Density (lb/cu ft)	Temp. Diff. deg F	Test U^b	F. H. A. Calculation U^b
Loose Fill	Blowing Rock Wool.....	1.0	5.0	44	0.312	0.202
	Blowing Rock Wool.....	2.0	5.0	60	0.216	0.116
	Blowing Rock Wool.....	3.0	5.0	64	0.142	0.081
	Blowing Rock Wool.....	5.5	6.0	80	0.095	0.046
	Expanded Mica	2.0	7.2	65	0.210	0.116
	Blowing Rock Wool, paper on top	1.0	5.0	42	0.268	0.202
	Blowing Rock Wool, rough pine floor.....	5.5	6.0	78	0.063	0.044
Bat	Bat A	1.73	3.6	68	0.140	0.131
	Bat C	1.75	2.1	51	0.154	0.130
	Bat B	3.25	3.0	74	0.111	0.075
	Bat C	3.5	2.1	54	0.113	0.070
Blanket	Blanket A	0.56	..	48	0.289	0.248
	Blanket A	0.65	..	61	0.207	0.227
	Blanket A	0.69	..	52	0.220	0.220
	Blanket A	1.12[a]	..	50	0.162	0.163
	Blanket B	1.20	..	54	0.129	0.155
	Blanket B	1.94	..	64	0.108	0.109
Uninsulated	.....	...	..	50	0.77	0.80

[a]Note: 2 blankets, each 0.56-in. thick, close together.
[b]U—Coefficient of Heat Transmittance expressed in Btu, hr^{-1}, ft^{-2}, deg F^{-1} (air to air).

Table 2—Apparent coefficients for rock wool

Thickness Inches	Apparent coefficient, K', for blowing rock wool
1	0.53
2	0.56
3	0.52
5.5	0.60

Table 3—Apparent coefficients for bat insulation

Manufacturer	Thickness Inches	Apparent Coefficient, K'
A	1.73	0.30
C	1.75	0.34
B	3.25	0.42
C	3.5	0.46

No change in the K value for blanket insulation is necessary to make the calculated values agree with these test values.

For the multitude of homes in the United States, with loose fill insulation in their ceilings and no attic floor, the rate of heat transmission upward through the ceiling can be materially reduced at little or no expense by merely placing a sheet of paper over the insulation.

DWELLINGS FOR WAR WORKERS

Construction of 8,222 new dwelling units for war workers, started during December by private builders operating under the FHA war housing insurance program, has been announced by Federal Housing Commissioner A. H. Ferguson.

Of these units, 7,188 were contained in 6,412 one-to-four family structures being financed by FHA-insured mortgages. This compared with 10,504 dwelling units in one-to-four family structures on which construction was started during November.

The remaining 1,034 units started in December under FHA inspection were in large-scale rental projects for war workers, financed under the terms of Section 608 of the National Housing Act. In November, construction was started on 889 units under this phase of the program.

The private war housing construction being financed by FHA-insured mortgages is part of the over-all war housing program administered by the National Housing Agency and conforms with all requirements and regulations for war housing established by the NHA and by the War Production Board.

Warship Ventilating, Heating and Air Conditioning

By Thomas H. Urdahl* and W. C. Whittlesey**

THE RESEARCH facilities of the ASHVE, and the consultant services donated by many of its members have been instrumental in improving and simplifying ventilation arrangements on fighting ships of the U. S. Navy. It is believed that the Society can be of further service to the war effort by acting as a medium through which to present the problem of warship ventilation to engineers engaged in the shipbuilding program.

Design facilities, fabricating plants, and shipyards are now being used that have had little or no background in naval construction. This has greatly increased production, but considerable improvement is necessary in matters of detailed design. Air conditioning and ventilation arrangements are often fitted in such a way that there are a few factors that develop undesirable results in otherwise satisfactory installations. Some of these items can be corrected when and if the ship has yard availability, but others are such an integral part of the ship's structure that proper remedial measures are virtually impossible.

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The opinions and assertions contained in this paper are the private ones of the writers and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

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SUMMARY—As the three prime factors in warship design are ordnance, protection, and speed, it is readily recognized that the ventilating, heating and air conditioning arrangements are complementary features. Several troublesome design factors are outlined that are peculiar to Naval work, which require that special attention be given to such items as minimum weight, watertight integrity, rugged construction and foolproof equipment. Air treatment provided for the various spaces on board ship is discussed and such other items are mentioned which stress the importance of balancing the system and standardization of equipment

Surface and submarine war machines are vital to military might, but they must be functionally designed and built to the best and most modern scientific and engineering standards to successfully engage enemy units. Traditional folklore to the effect that warship design requires a special fundamental approach is misleading—it is essentially sound engineering practice with the emphasis placed on factors rarely encountered elsewhere.

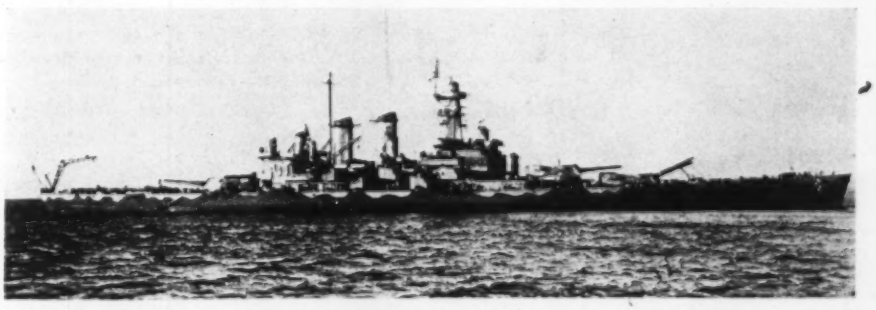
Special Military Requirements

Prime factors in a warship are ordnance, protection, and speed. Each of these factors is compromised to some extent in favor of the others because of over-all displacement limitations, and all three must be reduced because of other necessary complementary features. Consequently, it becomes vital to keep all secondary features to an absolute minimum of space and weight. Ventilating, heating, and air conditioning arrangements are complementary features fitted only to enable personnel to effectively fight the ship, and not to provide comfort conditions as usually required in commercial work. Some types of shore installations in industrial establishments might be called similar to the naval problem, although they differ in detail.

A successful commercial design is usually judged by the enthusiasm with which the installation is accepted, and the cost per unit of service. However, these criteria are not applicable to warship ventilation installations. A system that is eminently satisfactory to forces afloat is probably unnecessarily bulky and heavy, with the result that some ammunition or other vital equipment must be left ashore. Also, it is poor economy to simplify a ventilation system by reducing its resistance to damage, with the possibility of thus losing a ship.

There are a number of considerations or design factors that are peculiar to Naval work and result in practices that are difficult for the outside engineer to rationalize. The following items are presented as an explanation for factors that are troublesome to engineers encountering Navy Specifications.

1. *Minimum Weight:* The weight and space requirements for all equipment must be kept to the absolute



U.S.S. North Carolina (Official Photograph, U. S. Navy)

minimum consistent with satisfactory operation, and arrangements must be such that they restrict damage from flooding and fire. Small ventilation ducts are necessary to satisfy these requirements because they result in less weight and they afford greater protection because the piercings through water-tight and armored structure are smaller. The use of small ducts requires high velocities and fan pressures; however, this is preferable to increased weight and larger structural piercings.

2. *Watertight Integrity:* Ventilation ducts must not pierce main watertight structure below the highest possible waterline in order to provide protection against flooding in case of damage. This requirement necessitates circuitous leads, which combined with high velocities, complicate duct design. Ventilation piping must be designed to give uniform flow in the ducts to avoid noise and distribution troubles. In this connection it is important to use vanes in elbows and bends.

3. *Rugged Construction:* Warship equipment must be sufficiently rugged to withstand the shock of battle action and normal naval service. The shock caused by some types of enemy action produces accelerations in the hundreds of g's. Many ventilation systems are vital to the operation of the ship and must stand this strain to keep the ship in action. Brittle materials such as cast-iron, and too stiff or too flexible construction will cause failures. The temptation to include extra safety factors for warship equipment is great when the severe service requirements are realized; however, dependability should be provided by refinement in design and attention to detail instead of the arbitrary addition of mass, which inevitably results in pyramiding weight. Also, fighting men living and working in imminent danger of sudden death are inclined to play a bit rough. Space is congested, headroom low, and all ventilation fittings are within easy reach. Any gear that will not withstand a solid blow from an object such as a baseball bat is likely to have a short life span, and because of this condition substantial ducts of heavy gage metal are necessary.

4. *Foolproof Design:* Arrangements must be as foolproof as possible, designed to require a minimum of care, and installed to be tamperproof. The function of a warship is to fight, and the less the maintenance requirements are for complementary features the more time will be available for the principal business in hand. A large proportion of the sailors are mechanics and possess an insatiable curiosity about the why and wherefore of their environment. A traditional Navy requisite is for a man to know the purpose of every pipe, valve, and fitting at his station, and how it operates. Such individuals will soon discover that a change in a splitter setting will produce an increase in their ventilation, with the result that others are deprived of their proper share. Of course, such practices cause considerable distress, and no balancing device should be used that is easily adjustable or can be altered. For years splitter dampers or adjustable mechanical volume control devices were not permitted, and systems had to be balanced entirely by altering duct sizes or installing permanent orifice plates. However, many ship-builders found this method cumbersome and tedious, with the result that balancing was glossed over or omitted. Splitters are now acceptable, but they must be of such a design that they can be fixed in place by welding or riveting to prevent a clever sailor, with a screwdriver and a pair of pliers, from readjusting a system to his own liking.

5. *Insulation Variables:* The insulation problem on steel vessels is complicated because heat not only flows by transmission through bulkheads and decks but is also conducted long distances through the heavy steel structures. The heat from a fire room in the hold may be responsible for high structure temperatures on the second or main decks. The thickness of insulation ashore is usually chosen to give a minimum total for interest, depreciation, and operating costs for all equipment and fittings, but the thickness of insulation on a warship is chosen for a minimum total weight of insulation and equipment to produce cooling. This policy usually results in less thickness than is considered good practice ashore. The importance of good workmanship in fitting the insulation cannot be overemphasized as thorough covering is necessary. Air quantities for cooling are limited to a point where the resultant ambient air conditions approach critical temperatures — in other words, the designed conditions are as high as we can safely go. This is done to save weight. If the insulation is poorly fitted with a consequent increase in the heat gain over the values anticipated in the design, the resultant compartment temperatures will be too high. Designing so closely to limiting conditions may be poor practice elsewhere, but is absolutely necessary if our ships are to meet the enemy without already being half sunk by excess equipment. Weight limitations and rigid requirements for resistance to various kinds of damage and deterioration drastically restrict the acceptable insulation materials.

6. *Heating Arrangements:* Heating systems are designed to give acceptable performance with a minimum weight. This is usually accomplished by using fin tube steam heaters installed in the ventilation ducts. These are broken down into two sections—preheaters at the intake which raise the air temperature sufficiently to preclude condensation on unlagged ducts, and reheaters to raise the temperature of the supply air to the level required for heating a large space or group of small spaces of about the same exposure. This method does not provide the individual control which many desire, but it conserves weight. Care must be taken not to provide too much heat, for if shipboard compartments are maintained at ordinary comfort levels the men will not dress properly for topside duty.

7. *Exhaust Provisions:* There is a tendency to omit positive exhaust arrangements. Natural leakage through windows, doors or skylights on shore installations may provide adequate exhaust, but most shipboard spaces are watertight, gas-tight, or at least weathertight, and access doors or hatches must be kept closed at times when ventilation is most needed.

8. *Weather Openings:* Weather ends of both supply and exhaust systems must be designed and located to expel sea water in rough weather and to prevent air recirculation between supply and exhaust openings. Ventilation cannot be secured in spaces such as engine rooms regardless of the weather, and sea water entering through the ducts will cause casualties to electrical equipment. Also, closing down the ventilation to living spaces during foul weather is very disagreeable and not at all conducive to a fighting attitude. The satisfactory location of openings is difficult since warships are designed with as little superstructure as possible to reduce the area outside of primary protection, and to provide the maximum possible train for the battery. Also, director foundations and other fittings produce eddy currents that vary with the relative wind direction and force. This crowded condition and variation of turbulence often result in recirculation problems. The best way to avoid the trouble is to have supply openings on one side of the vessel and exhaust openings on the other; however, this is seldom practicable, and the designer must often make the best arrangement possible under difficult limitations.

9. *Universal Weather Design Conditions:* A fighting ship must be capable of operating in any navigable sea in the world at any season of the year. This requires cooling and heating systems that will provide adequate conditions in the Arctic in winter or the Tropics in summer, and a wider range of operating conditions is necessary than is usually encountered ashore.

10. *Corrosion Problem:* Continuous exposure to sea water and salt air result in a difficult corrosion problem, and many materials and coatings that have provided satisfactory protection ashore have failed afloat. Consequently, the Navy is skeptical of new developments and requires rigid and extensive tests of new proposals regardless of their previous record.

11. *Personnel:* The problems are somewhat simplified because all personnel are healthy male specimens, better able to adjust themselves to relatively extreme conditions than the average person. However, many individuals seem to be totally unaware of their remarkable ability in this matter and complain bitterly about the conditions to which they are subjected. This situation is at least partially chargeable to the comfort cooling standards developed by the industry for theaters, hotels and other public buildings. Considerable diplomacy is necessary in handling these complaints—it only antagonizes people to quote experiments proving that human protoplasm will remain in good working order at conditions outside of the comfort zone.

Outline of Treatment

The treatment required for the various shipboard spaces is determined by the basic use of the compartment and the type of ship on which the installation is to be made. The treatment may be roughly divided on the basis of the spaces served: (1) berthing and messing spaces; (2) working spaces; (3) control spaces; (4) heat producing spaces; and (5) stowage spaces.

The atmospheric conditions that prevail in living compartments aboard a warship have an important bearing on the health and morale of the crew, and the maintenance of satisfactory berthing and messing space temperatures is a naval necessity. Shipboard tests have demonstrated that personnel can work effectively and efficiently in extreme atmospheric conditions over extended periods of wartime cruising so long as there is a reasonably comfortable place in which to relax when off watch. A sailor's duties in war are varied, and often his free time is broken up by extra duty or alerts. Consequently, it is doubly important that living space conditions are conducive to adequate rest.

Living spaces are now cooled by means of ventilation, *i.e.*, fresh air is circulated through a vessel to provide cooling in the same way jacket water cools an engine or air cools an automobile radiator. The quantity of air provided is based on maintaining a specified temperature rise over outside air or providing a given minimum quantity per man, whichever is the greater. The exposure of living spaces and the heat producing machinery located therein varies greatly for different locations and for different types of vessels; consequently the design cannot be governed by an air change method.

The distribution problem is complicated by the density of occupation in berthing spaces, the large air quantities, and the headroom which is barely sufficient to provide clearance for personnel. Overhead distribution through ducts and registers in such spaces has resulted in objectionable drafts, and a method of diffusing air against the deck has been developed that is quite successful. Distribution for messing spaces is usually through overhead ducts fitted with diffusing terminals. The exhaust is centrally located, care being taken not to short circuit supply air.

Cooling with Air

The ventilation method of cooling results in inboard conditions of about 10 F above topside air. Weather air in the tropics may be as high as 90 F dry-bulb and 80 F wet-bulb for weeks on end, and under such conditions it is impossible to maintain satisfactory temperatures in living spaces with ventilation only. A rise of 10 F dry-bulb and 4 F wet-bulb over the above conditions would result in 89 deg ET. A person exposed to such conditions will perspire profusely and sleep lightly. Although this will not produce any measurable deleterious effect over short periods, extended exposure will dull alertness, dexterity, and both physical and mental processes. One of the most striking examples of reduced efficiency is shown by a comparison of the time it takes a sailor to awake and take such action as the particular situation demands under different temperature conditions. In cool weather this is accomplished in almost nothing flat, amid loud and sundry grumblings garnished lavishly with appropriate epithets; but under tropical conditions many minutes are required for the men to crawl slowly and listlessly out of their berths and become cognizant of the situation at hand. The reactions of these bewildered individuals provide considerable amusement for their contemporaries already on watch, but in case of a surprise enemy attack this situation is anything but humorous.

Mechanical Cooling Limitations

Air conditioning, or more accurately, mechanical cooling, appears to be the only practical answer; but regardless of its desirability it is not generally applied because of concern over the dependability of the equipment together with the required increase in weight. A recent comparative study showed that the use of a single unit air conditioning system for a group berthing space would result in a weight increase of 88 per cent over that required for ventilation. Although this system would provide satisfactory temperatures during tropical cruising, whereas ventilation will not, the weight increase is absolutely unacceptable. The application of air conditioning to living spaces aboard warships must await the development of equipment that can compete more favorably with the present ventilation systems in dependability, weight, and space requirements.

Working Spaces

Shops and other similar working spaces are cooled by ventilation. The quantity of air provided is based on maintaining a specified temperature rise and in providing a minimum air change if any inflammable or toxic vapors are likely to be present. Distribution is usually through diffusing terminals in the overhead with the exhaust located over heat sources such as a forge or bending slab. This arrangement has proved satisfactory in service.

A few vital control spaces on the larger vessels are air conditioned by self contained units to maintain ideal working conditions, and to permit these compartments to be positively sealed from any source of fire or flooding. Dual units are provided to give dependability, but each is selected to maintain an emergency condition which is barely habitable, such as 103 db and 85 wb. This reduces the required tonnage and the necessary weight and space. The controls for these units are adjusted for comfortable temperatures instead of the designed values, and the use of both units simultaneously will provide suffi-

cient tonnage to maintain low temperatures at any time. Inasmuch as the selection is based on the battle load, one unit is usually capable of maintaining comfortable conditions whenever the crew is not at battle stations; and should one unit fail during battle, the other will maintain the emergency condition.

Hot Spaces

The concentration of heat producing equipment in machinery spaces such as the engine and fire rooms is so great that satisfactory conditions cannot be maintained throughout every part of the compartment. Even if this were possible, its desirability is questioned, for a tremendous quantity of energy is removed by the exhaust air in the form of heat and increasing the ventilation over present standards would mean increasing this heat loss and thus reducing the plant efficiency. This point may be emphasized by equating the horsepower equivalent of the heat energy removed by the ventilation air to the horsepower required to propell the ship. On one ship this power was equivalent to that required to drive the ship at nine knots. Attempts have been made to use air conditioned control booths or cubicles for personnel, but these have met with disfavor, for it is believed that operating personnel should be constantly in close contact with the machinery. Preliminary experiments have also been conducted in the use of ventilated suits, but this meets with the same basic objection of restricting freedom of movement. The ships' engineering officers are of the opinion that the men are there to service the equipment—and are naturally opposed to radiant heat shields or any other gadget that interferes in the slightest degree with machinery accessibility or maintenance.

Spot cooling of operating stations and normal working areas is the method used to ventilate heat producing spaces. This is accomplished by means of a large jet or blast of supply air delivered directly to the watch stations, thereby giving the watchstanders the benefit of the weather air before it has been heated by the equipment. The air blast arrangement also reduces the effective temperature of a given wet- and dry-bulb combination by increasing the air velocity over the body. Adjustable terminals are required for this service, and they must be installed in such a way that the blast will sweep the working area and can be directed against the front of the operator's torso. If it is directed on his head or the back of his neck, discomfort will result in even the hottest compartments. Personnel served by spot cooling can leave the *oasis* for a sufficient time to service machinery in the hot portions of the space. Portable blowers are rigged in case emergency repairs are necessary.

Exhaust arrangements in hot spaces require particular attention. The exhaust fan capacity must be in excess of supply fan delivery not only because of the expansion of the ventilating air due to the temperature rise, but also to induce an indraft through the space access. If this is not done, hot air from machinery spaces will circulate upward through the ship and overheat the living or working spaces through which it passes. Such a condition can make a miserable ship out of what might otherwise be a well ventilated vessel. Exhaust should be through large bell mouth terminals in the overhead above the principal heat sources.

Ventilation is vital to the operation of a machinery space, and great care must be taken to assure dependable operation. Tests have proved that many machinery spaces cannot be manned longer than a few minutes should the ventilation fail; consequently, high ambient temperature motors are used for these fans, and duplicate power circuits are often fitted to insure dependability. Also, fans should be installed in protected locations.

Considerable improvement can be made in heat producing spaces by thorough and complete lagging. Every pipe, every flange, and every valve bonnet on hot piping must be covered. Decks, bulkheads, frames, and stiffeners should also be thoroughly insulated to reduce the heat transmission and conduction through the ship's structure to cooler compartments. Every square inch of surface should be properly covered. A recent investigation showed that the omission of the lagging from a steam line flange and from about one square foot of the overhead in way of this flange resulted in the overheating of a magazine group that was located above. To repeat again, shipboard insulation is used sparingly to save weight, and it is necessary to have complete coverage. Good workmanship is absolutely necessary for effective insulation and lagging applications aboard ship. The standard procedure is to have the lagging gang cover everything that is possible to cover, and then go ahead and cover the impossible with insulating cements or any other feasible material. The practice of omitting lagging to facilitate repair should be discouraged, as it inevitably results in overheated spaces. The removal and replacement of lagging should be considered just as much a part of repairing a valve as fitting the flange gaskets.

Storage Spaces

Stowage spaces are treated on the merits of each case. Ventilation is used only as a last resort, as the majority of storerooms are either low in the ship or in outboard spaces provided essentially for protection, and the necessary holes for ventilation ducts constitute a flooding hazard that is always undesirable and often unacceptable. No treatment whatever is provided if there is a good chance that the material stowed will not be functionally affected. Shore standards of maintaining appearances to preserve salability are ignored. Desiccants are used where moisture removal is necessary and ventilation is used only where cooling is required. Possible explosive concentrations in compartments adjacent to inflammable liquid stowage are controlled either by ventilation or by maintaining atmospheres that will not support combustion.

Refrigeration is provided for some types of storerooms other than cold storage boxes where a definite maximum temperature must be maintained and where the boundary piercings required for ventilation are unacceptable. Dual compressor units are installed to provide dependability, and dual coil installations are fitted in each space

served. Spaces are grouped conveniently for cooling with due regard for compartmentation and probable damage. Gravity evaporator coils installed in the overhead are generally used for this type of service. The capacity of each set of coils is chosen to hold a maximum permissible temperature as a weight saving expedient, and a manufacturer may be requested to refrigerate a space to 90 F. The control thermostats are set for much lower temperatures which can usually be maintained by one unit except when the ship is operating at maximum power in the tropics or in battle condition.

Balancing Is Essential

One of the biggest problems in warship ventilation is to get the systems properly balanced before delivery of the vessel. Balancing is the adjustment of a system to compensate for errors in the design, fabrication, and installation of the ducts to provide the proper quantity of air at each terminal. All the blood, sweat, and tears that are expended on a ventilation system are utterly wasted if this end is not achieved. There is too much of a tendency to consider an installation complete when all ducts and other fittings are in place and the fan is turning over. True, the work is over 99 per cent complete, but the system will be only partially effective, and in many cases totally unacceptable, if not properly finished by balancing. The results of unbalance are rarely apparent during the building period and preliminary trials since air quantities are based on full power wartime operation in the tropics, with all auxiliary equipment in use and a full complement living aboard. Consequently, maximum ventilation is not essential in home waters and few complaints are made until after the ship has left the building yard.

Furthermore, the possibility of more equitably distributing the available air never seems to occur to forces afloat, and in cases of unbalance additional ventilation is usually requested. Such emergency alterations, completed during restricted availability at an advanced base, invariably increase weight out of proportion to the improvement and often result in arrangements that are not properly installed to resist damage.

Adequate and accurate tests are required to properly balance a ventilation system. The testing of ventilation systems under the most ideal conditions is trying and seems to be a controversial issue; but the average system aboard a warship is believed more difficult to test than the worst system elsewhere. The complicated intakes, the large number of offsets, bends, elbows, fittings and transition sections that are necessary to run the average duct in the restricted space available all contribute to turbulence and complicate measurements. However, a simple technique has been developed for volumetric tests, based on the much maligned rotating vane anemometer, in which readings taken at various points of a system and by different individuals show remarkably consistent results.

Standardization of Equipment

The equipment used for ventilating, heating, and air conditioning arrangements must be simple, rugged, light, reasonably quiet, and economical as to power requirements. As the supply of critical materials becomes more acute and rationing becomes more detailed, it is necessary to plan accurately for future needs in order to obtain the required allocations. It is also vital to place large orders to permit manufacture on a quantity production basis. This can only be done by standardization and anticipating requirements. In the present building program it has been found necessary to maintain stocks of ventilation equipment to avoid delaying completion dates on new construction, and to expedite conversions and repair.

Stocks of standardized equipment must also be maintained at advanced repair bases to care for battle damage. This requirement becomes more and more urgent as the frequency of engagements increases. The speed with which damaged ships can be reconditioned for battle will have an important effect on the course of action, for with anything approaching equal forces in a given theater, victory may be determined by the speed with which a shipyard can refit damaged vessels. This one factor is ample reason for equipment standardization and a large investment in equipment stocks.

Furthermore, standardization is a great boon to the designer. In the days of competitive bidding on individual manufacturer designed equipment, the ventilation and heating contract was rarely let until after the deadline for working plans, with the result that the designer never knew just what his equipment dimensions or performance characteristics would be. Now the designer knows exactly what he will get, what it will do, and its dimensions. Obviously, a standardized fan line will limit the range of selection, and it is now necessary to design the ducts to suit a given fan, rather than to choose a fan to suit a given duct design. This policy created some confusion at first but is now showing good results.

Ventilation fans were the most difficult to develop and standardize. The success of this venture was made possible by the cooperation of the fan manufacturers and their willingness to expend funds in the development of a fan to meet Navy requirements. There was a trying interlude when the Navy did not seem to know exactly what it wanted, or whether it would be able to purchase such fans under the competitive schedules after development; however, everyone kept plugging away on the problem and an excellent product finally emerged. This fan is small and compact, satisfies the Navy requirements as to ruggedness, operates direct connected at high speed with a low noise level, is capable of developing high pressures, but can operate satisfactorily down to free delivery, is readily adaptable to watertight applications, has limit load power characteristics, is so efficient that power requirements are very low, and is capable of being installed in much less space than was formerly required. A recent development provides a simple mechanical volume control.

All in all, this standard fan description probably sounds like the answer to a maiden's prayer. It is. Before its advent, all attempts to use high pressure fans had produced noise levels in living and con-

trol spaces that were actually detrimental to the crew's health and adversely affected ship operation. During this period the reception of ventilation representatives aboard ship may be described as *restrained*. They were assigned staterooms so noisy that conversation was impossible—in one case the noise level on the berth pillow was measured at 93 db. The use of the new fan has practically eliminated the noise problem, and personnel afloat have returned to their time honored complaint of uncomfortable temperatures.

Other equipment is also standardized or in the process of being standardized. Standard plans for heaters, convectors, watertight closures, diffusing terminals, and duct elbows are now available, although development is continuing on this equipment. Standardization is the key to equipment procurement, and it is anticipated that difficulties will vary inversely with the degree of standardization that can be developed and maintained during the present emergency. Manufacturers are called upon to assist in the standardization program as it is believed that this will not only develop better equipment for the Navy, but will also ultimately result in improved equipment for the industry as a whole.

Considerable difficulty has been experienced with evaporator coils furnished for air conditioning installations. The various manufacturers vary widely in their coil selections for a given application, and it has been necessary to replace some coils in order to develop the maximum tonnage of which the compressors were capable. Evaporator coil workmanship has often been disappointing, and some types foul so quickly and are so difficult to clean that their usefulness aboard ship is seriously curtailed. The Navy is now conducting an investigation to determine the acceptability of various coil types and to develop a standard for naval applications. The purpose of this study is to provide satisfactory installations and to insure a maximum output per pound of equipment.

Conclusion

Progress in warship construction can only be made by providing more punch per pound, and a naval engineer should strive to develop lighter, simpler, and more foolproof methods to accomplish this end. Conventional practices should be continually analyzed from the functional standpoint and revised wherever commensurate savings in weight or space are possible, or where dependability can be improved.

Whenever a member of this society is solicited for technical assistance regarding Naval construction, he should consider it his patriotic duty to apply the principles outlined herein. Sailormen are fighting to the death on the high seas in our battle with the enemy. It is our responsibility to provide them with the best fighting ships it is humanly possible to build.

LONG OVERDUE BUT LEAVES AUTHORITY DIVIDED

Chairman Donald M. Nelson, in a letter to Petroleum Administrator for War, Harold L. Ickes, has outlined the division of responsibility between WPB and PAW in connection with actions affecting the petroleum industry, according to an official announcement issued January 13, 1943.

Mr. Nelson's letter, which was confirmed by Mr. Ickes, dealt with the relationship of the two agencies under Executive Order 9276, which delegated to Mr. Ickes authority to determine policies and take actions relating to the industry.

The letter was based on *our mutual understanding*, Mr. Nelson wrote. It stated the relationship as follows:

1. Under Executive Order 9276, the Administrator will issue directives and orders to the petroleum industry relating to the production, refining, treating, storage, shipment, receipt and distribution within the industry of petroleum, petroleum products or associated hydrocarbons as defined in the order. To avoid confusion with WPB actions, the Administrator's actions will be designated as *petroleum directives* or *petroleum administrative orders*.

2. The Administrator also may take action, to the extent specified in the order, concerning the distribution within the industry of other products or material, including the granting or denial of priority, allocation or preference rating assistance to the industry. Such actions will be subject to program determinations and other directions of the WPB chairman and will be issued in the name of WPB's Director General for Operations. The Administrator's signature will appear on such documents so that the industry will be able to distinguish between actions originating in WPB and those originating with PAW.

3. The Administrator will give WPB reasonable advance notice and opportunity for consultation before taking any of the actions outlined, excepting in case of an emergency, by mutual agreement with certain WPB officers, or in cases where the proposed action will not affect more than two members of the industry, provided the members do not represent the majority of the particular branch of the industry affected.

4. WPB will continue to give the Office of Petroleum Coordinator for War reasonable notice and opportunity to be heard concerning all actions which might affect the petroleum industry, subject to the same exceptions as those set forth above.

5. The Administrator will give WPB five days' notice before taking action affecting products or hydrocarbons not deemed to come within the definition of petroleum products and associated hydrocarbons contained in the Executive Order.

6. The Administrator will provide the means for enforcing all *petroleum directives* or *petroleum administrative orders*.

7. As soon as possible, WPB orders which come within the provisions of paragraph 1, will be reissued by the Administrator, and the WPB orders will be revoked. This includes L-70, regulating shipments of motor fuel, and all orders in the M-68 series, which deal with petroluem production and marketing material and conservation of petroleum material.

Procedures for giving the notices referred to in paragraphs 3, 4 and 5, will be worked out between PAW and the Deputy Director General for Distribution of WPB. Additional procedures for the presentation of the petroleum industry's requirements to WPB are still under discussion, and will be determined as soon as possible.

WEATHER BUREAU CHIEF RECEIVES LOSEY AWARD

F. W. Reichelderfer, Chief of the U. S. Weather Bureau, was among those honored by the Institute of the Aeronautical Sciences at its Honors Night Dinner at the Waldorf-Astoria, New York, January 26. Mr. Reichelderfer received the Robert M. Losey Award given annually in recognition of outstanding contributions to the science of meteorology as applied to aeronautics.

He has been chief of the Weather Bureau since January 1939. From 1919 he had been a Meteorological Officer in the U. S. Navy, in which he now holds the rank of Commander (retired). In the presentation of the Losey Award Mr. Reichelderfer was cited for his pioneering work and continuing activity in advancing the science and practice of meteorology as applied to aeronautics, with particular recognition of the development under his direction of the network and system of upper air sounding by radiosonde.

Among the many developments made in the services of the Weather Bureau under Mr. Reichelderfer's direction has been the extensive use of upper air observations made by radiosonde or radiometeorograph. This is an instrument which automatically transmits weather data by radio to a ground station as it is carried aloft by a balloon to very high altitudes. Widespread use of these and other improved instruments and techniques in the Bureau's regular practice has enabled it to provide better weather forecasting service for the special needs of aviation and essential war industries under war conditions.

The Losey Award is named in memory of Capt. Robert Moffat Losey, a member of the Institute and a meteorological officer of the U. S. Army Air Corps, who was killed during an air attack on Dombas, Norway, April 21, 1940, while serving as an official observer for the U. S. Army. He was the first officer in the service of the United States to be killed in World War II.

Mr. Reichelderfer has served as a member of the ASHVE Research Technical Advisory Committee on Weather Design Conditions since 1939.

JOHN JAMES JOINS IRON FIREMAN

On February 1, John James started some new duties with the Iron Fireman Manufacturing Co., Cleveland, O., after 7 years' service as Technical Secretary of the American Society of Heating and

John James

Ventilating Engineers, New York, N. Y.

Mr. James' responsibilities with the Society since 1935 have included the preparation of the technical data for the annual edition of The Guide, the correlation and administration of the cooperative research program of the ASHVE, and work with code and technical committees.

After graduation from Oregon State College in 1928, Mr. James did consulting work in Portland, Ore. Four years later he was awarded a research fellowship at the University of Wisconsin, where he received a master of science degree in 1934, and then entered the research field through General Electric Co., Schenectady, N. Y. He is the author of a number of technical articles and is a member of Sigma Xi, national honorary scientific society.

He is widely known to members of the ASHVE through his many appearances as a speaker at Society and Chapter meetings, and is held in high esteem by the Chairmen and members of the various committees with whom he has been associated.

Mr. James enters his new field of activity with the best wishes of the officers and Council of the Society.

SEARCH FOR SPECIALISTS

The United States Civil Service Commission, Washington, D. C., recently began a nation-wide search for the production specialists who will administer War Production Board's new Controlled Materials Plan. The Controlled Materials Plan, designed to balance essential industrial production against available stockpiles of critical materials, will go into operation in 1943.

Applications are not sought from persons already using their highest skills in war work. Urgently sought right now are persons with industrial or engineering experience in the fields of copper, aluminum, carbon steel, and alloy steel. Also highly important to this program are those with such experience in (1) machine tool and machinery production; (2) electrical and communications equipment; (3) transportation equipment, such as aircraft, ships, and railroad motive power, and rolling stock; (4) engineering materials such as plastics, rubber, and construction materials.

Head Specialists will receive $6,500 a year; others $4,600 and $5,600 a year. Many positions, however, must be filled at salaries ranging from $2,000 to $3,800 a year. Jobs are located in Washington, D. C., and throughout the nation.

Holders of war contracts who need workers with certain important skills are requested to make these requirements known at once to all local offices of the United States Employment Service, according to an announcement of the War Manpower Commission. The 25 special skills for which an intensive drive is being undertaken are:

Airplane skin man, airplane subassembler, ammunition inspector, ship assembler, metal work bench hand, bus driver, ship carpenter, cord wood cutter, crane rigger, cylindrical grinder operator, ship driller, electrician (ship), flanging press operator, internal precision grinder, out-

side machinist, metal operator, metal chipper, milling machine operator, explosives mixer operator, radio chassis assembler, rough or finish ship painter, plate hanger, automatic or semi-automatic screw machine operator, tack welder, and licensed marine engineer.

A nation-wide search for men and women who have ever been employed in these occupations or who are now engaged in such work in non-war industry is now proceeding and will be continued until February 28. Appeals to persons so qualified to register at their nearest United States Employment Service office are being made by radio, by special posters, and through the press and various national magazines.

Available openings for such workers, if listed immediately, will enable the United States Employment Service to refer such workers as may be discovered to specific jobs without delay. This procedure, the Commission points out, will assure the placement of needed men in important war industries.

ADVISORY STANDARDS FOR YOUNG WORKERS

In a move to protect young workers entering wartime industry, Katharine F. Lenroot, Chief of the Children's Bureau of the United States Department of Labor, recently announced that the bureau is setting up a series of advisory standards pointing out the hazards of various occupations in which young workers are likely to be employed and listing kinds of work that are relatively safe or unsafe for boys and girls 16 and 17 years of age.

In announcing these advisory standards, the bureau urges the voluntary cooperation of the thousands of employers in war industries in adopting employment and training practices in respect to youths aged 16 and 17 that take into account both the relative hazards of specific occupations and the added factor of risk owing to youth and inexperience.

The accident rate, Miss Lenroot pointed out, is also on the upgrade. No separate statistics for young workers have been compiled she said, but the frequency rate for industrial accidents, which means the average number of injuries per million hours worked, was 14 per cent higher in 1941 than in 1940, an increase attributable to the influx of large numbers of inexperienced workers into the war industries, the overcrowded conditions of work in the wartime factories, and the failure of safety activities to keep fully abreast of the war program. Work accidents occurring in 1941 deprived the United States of 251,000,000 man-days of actual and potential production time. This figure is based both on the loss incurred in that year and the loss to production time in later years represented by deaths and permanent disabilities. This loss is equivalent to the full-time employment for a year of more than 800,000 workers.

FUEL RATIONING BOARD COMPLIMENTS KANSAS CITY CHAPTER

A tribute from Eugene Lyon, Kansas City, Mo., Chairman of the War Price and Rationing Board, Fuel Oil Rationing Division, to the members of the Kansas City Chapter of the ASHVE has been received. Mr. Lyon stated that:

> Not alone did they give of their time in the handling of the highly technical questions brought before us, but they gave of themselves in a most creditable manner whenever they were called upon to do so.
>
> What success we have had in handling this intricate rationing project is largely due to their efforts: E. K. Campbell, W. A. Russell, E. Richards, M. M. Rivard, J. M. Arthur, Jr., D. M. Allen, Emil Haas, and T. D. Fitzmorris.

SQDN. LDR. FOSTER KILLED IN ACTION

Known in the R. A. F. as the *Flying Plumber*, Sqdn. Ldr. Phil H. Foster, Flin Flon, Manitoba, Canada, was reported killed in action near Stavanger, Norway, where he was buried, according to word received recently by his family.

He was born in Melfort, Sask., on September 22, 1909, where he received his early education. Following his graduation from the Daniel MacIntyre High School, he attended the University of Manitoba. At a very early age he became a helper in the General Plumbing and Heating Co., Winnipeg, Man., and in 1928 became journeyman for Bowyer-Boag, Ltd. He was also employed by H. C. Nixon Plumbing Co., Saskatoon, Sask., and with John Colford, Montreal. In 1932 he became superintendent for the Provincial Government of Saskatchewan, Prince Albert, Sask. Later that year he became manager and superintendent of Hudson Bay Plumbing Co., Flin Flon, Man., of which he was owner.

In 1939 he passed his final tests in flying, at which time he received

Phil H. Foster

his *wings* as a private pilot. In 1939 he was rejected by the Royal Canadian Air Force because of his age, but he paid his passage to England and joined the R. A. F., where he received quick promotion from pilot officer to squadron leader. For a time in 1940 he was stationed at Trenton, Ont., as an instructor in the R. A. F.

In one engagement he was shot down in a bomber and spent several months in a hospital, later rejoining his squadron.

He was a prominent citizen of Flin Flon, Man., and was Past President of the Flin Flon Rotary Club and the Board of Trade, Past Exalted Ruler of the B. P. O. E., and a member of the I. O. O. F.

It has been announced that the will of Phil Foster provides $10,000 for the Flin Flon Rotary Club for community service. The will states that $1,000 be paid annually to the service club from Hudson Bay Plumbing Co., which the flier owned.

The Officers and Council of the Society extend their sincere and heartfelt sympathy to his parents, Mr. and Mrs. K. Foster, Brooksby, Sask. He was a valued member of the Manitoba Chapter, whose members will miss his genial presence and cheery disposition.

SUMMARY OF LOCAL CHAPTER MEETINGS

Chapter	Meeting Date	Subject	Speakers	Other Features	Attendance	Attendance Ratio*
New York	January 18	Panel Heating.	Peter B. Gordon.	Joseph Wheeler, Jr., was presented with Chapter's past president's gift by Alfred J. Offner.	75	0.4
Northern Ohio	January 11	Frozen Foods.	Dr. D. K. Tressler.	Joint Meeting with American Chemical Society. Coffee speaker, local OPA representative.	150	2.7
	December 14	Has the United States Patent Office Outlived Its Usefulness.	W. A. Evans.	Election of Delegate and Alternate to Annual Meeting.	14	0.25
Ontario	January 11	Gas.	W. Philpot, Works Supt., Consumers' Gas Co., Toronto. A. J. Strain, Supt. of Domestic Sales, Consumers' Gas Co.		48	0.53
	December 7	Food Dehydration.	M. B. Davis of Dominion Horticulture Dept. of Agriculture, Ottawa.		86	0.55
			C. C. Eidt.	Slides on Method of Drying Foods. Mr. H. R. Roth appointed as delegate for the 49th Annual Meeting at Cincinnati. D. O. Price and H. R. Roth as alternate appointed to the Nominating Committee for 49th Annual Meeting.		
Pittsburgh	January 11	"It Ain't the Heat, It's the Enthalpy."	Dean John A. Goff, Dean of Towne Scientific School. University of Pennsylvania.		65	0.72
	December 14	Wartime Rackets.	Eugene A. Holland.		18	0.3
Western Michigan	January 11	General Consideration of Domestic Fuels and the Situation at the Mines.	Minotte Brooke, Asst. Fuel Eng. of C. & O. R. R.	Discussion of proposed amendments to the National Constitution and By-Laws.	40	0.75
		Adjustment of the Petroleum Industry to the War Effort.	Vern W. Skinner, Sales Mgr. with Mid - West Refineries.			
	December 14	Keeping Existing Equipment in Good Repair.	A. H. Snook, Filters. P. O. Wierenga, Fans & Motors. L. G. Miller, Stokers, Oil/Gas Burners. L. A. Tilford, Controls.		15	0.28

Chapter	Meeting Date	Subject	Speakers	Other Features	Attendance	Attendance Ratio
Atlanta	December 29	Summary of Year's Activities.	Pres. L. F. Kent.	T. T. Tucker and President Kent were elected Delegate and Alternate to Annual Meeting. New Officers elected: Pres., A. H. Koch; Vice - Pres., M. M. Crout; Sec'y., L. F. Lawrence, Jr.; Treas., I. B. Kagey.	9	0.18
South Texas	December 28			It was approved that officers be continued in office for 1942-43: A. J. Mitchell is to fill office of R. M. Spencer until next election of officers. A. M. Chase, Jr., is to assume duties of Treasurer as well as those of Secretary. J. A. Walsh appointed Delegate and A. J. Rummel as Alternate.	7	....
Wisconsin	December 21	Fuel Oil Rationing.	Leonard Campbell.	Discussion of the proposed change in the method of selection of Society Officers and Council Members.	28	0.40
Cincinnati	December 19	Christmas Cheer Party.	Santa Claus.	Round Table Fellowship.	26	0.59
Massachusetts	December 15	Heating & Ventilating of Ship.	H. E. Parker.	Announcement made of the nomination of Prof. James Holt to the Council.	28	0.48
Nebraska	December 15	Summary of All Papers Presented at Semi-Annual Meeting in St. Paul.	W. R. White.	Election of Officers: Pres., G. E. Merwin; Vice-Pres., B. G. Peterson; Sec'y., E. F. Adams; Treas., D. E. McCulley; Board of Governors, W. R. White and R. B. Saxon. B. G. Peterson and W. A. Goll were elected Delegate and Alternate to Annual Meeting.		
Illinois	December 14	"Fuel Oil Rationing Problems in the Chicago Metropolitan Area."	Mr. M. S. Kilgallon, Fuel Oil Rep., Chicago Met. Area, OPA. Mr. D. E. Larish.	A very interesting open discussion followed, which brought out answers to some of the questions which were presented.	79	0.568
Montreal	December 14	Picture — Laying Montreal—Portland Pipe Line and Travelogue on Africa.		Officers elected: Pres., F. A. Hamlet; Vice-Pres., A. M. Peart; Treas., J. B. Dykes; Sec'y., R. R. Noyes. Board of Governors, F. G. Phipps, R. F. Wormley, T. H. Worthington, W. W. Twizell and A. B. Madden.	39	0.57
Manitoba	December 11	Motion Pictures.	B. J. Dalzell.	Social evening after Chapter business had been attended to.	33	0.58

Chapter	Meeting Date	Subject	Speakers	Other Features	Attendance	Attendance Ratio*
Kansas City	December 10	The Victory Twins—Electricity and Oil.	H. E. Dralle, Mgr., Petroleum and Chemical Engineer Division, Westinghouse Electric & Mfg. Co.	Joint meeting with *ASME, AIEE, AIA, MSPE.*	75	0.35
Philadelphia	December 10	Tremendous Trifles of Army Ordnance.	Thornton Lewis, Deputy Chief of Production, Service Bureau.	Sound movie.	60	0.50
Iowa	December 8	Automatically Fired Plants and Heating Problems.	F. L. Walters.	Discussion on Humidifying Equipment.	11	0.35
Golden Gate	December 2	Air Conditioning and Ventilating of Cargo Vessels.	Lawrence Dake.		29	0.48
Southern California	December 2	Load Design and Methods of Installation.	H. M. Hendrickson.	A very interesting open discussion followed this meeting which was joined in by many of the members present.	43	0.37
		Central Air Conditioning Systems *vs.* Multiple Type Systems.	Maron Kennedy.			
		Controls for Air Conditioning Systems.	W. O. Stewart.			
St. Louis	December 1	Fans and Their Application.	John W. Cooper, Buffalo Forge Co., St. Louis, Mo.		18	0.31

* The attendance ratios shown represent the meeting attendance divided by the Chapter membership. These will be useful as a partial indication of interest shown by local chapter members in various types of subjects programmed by other local chapters, and may be helpful in deciding on subjects for other chapter meetings.

Candidates for Membership

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the Journal of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 30 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by February 15, 1943, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
Abbott, Furman S., Engr., Frank A. McBride Co., Paterson, N. J.	A. L. Hard E. J. Richard	H. E. Sproull G. V. Sutfin
Berres, Daniel S., Assoc. Naval Archt., Bureau of Ships, Washington, D. C.	T. H. Urdahl C. M. Sterne	W. C. Whittlesey G. P. Lively
Boggs, Dennis, Engr., Avery Engineering Co., Cleveland, Ohio	E. J. Richard G. V. Sutfin	H. K. Jennings H. E. Sproull
Brown, Guy M., Minneapolis, Minn.	A. B. Newton W. F. Uhl	R. W. Otto W. McNamara
Carson, Clyde C., Engr., Bureau of Ships, Washington, D. C. (*Reinstatement*)	E. R. Queer F. C. Houghten	T. H. Urdahl W. C. Whittlesey